

Figure 1: Categories of Defects in Sewer Pipes



Figure 2: Root Intrusion



Figure 3: Dirt Deposits

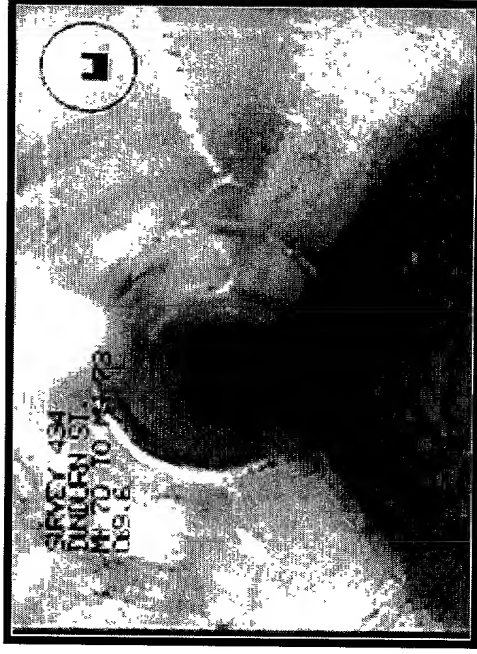


Figure 5: Cracks

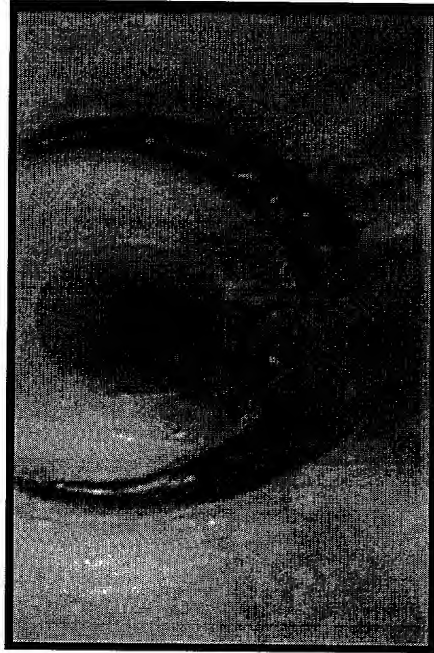


Figure 4: Infiltration

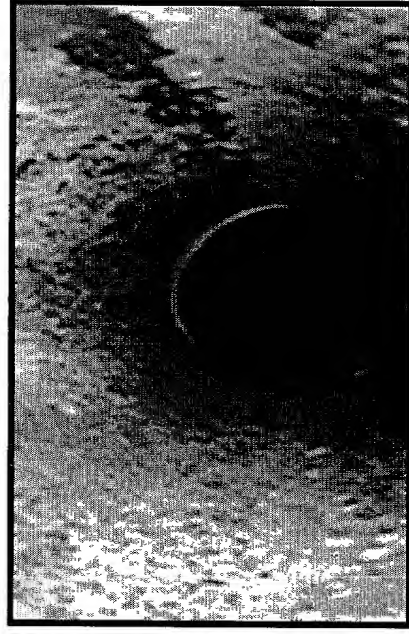


Figure 6: Misalignments

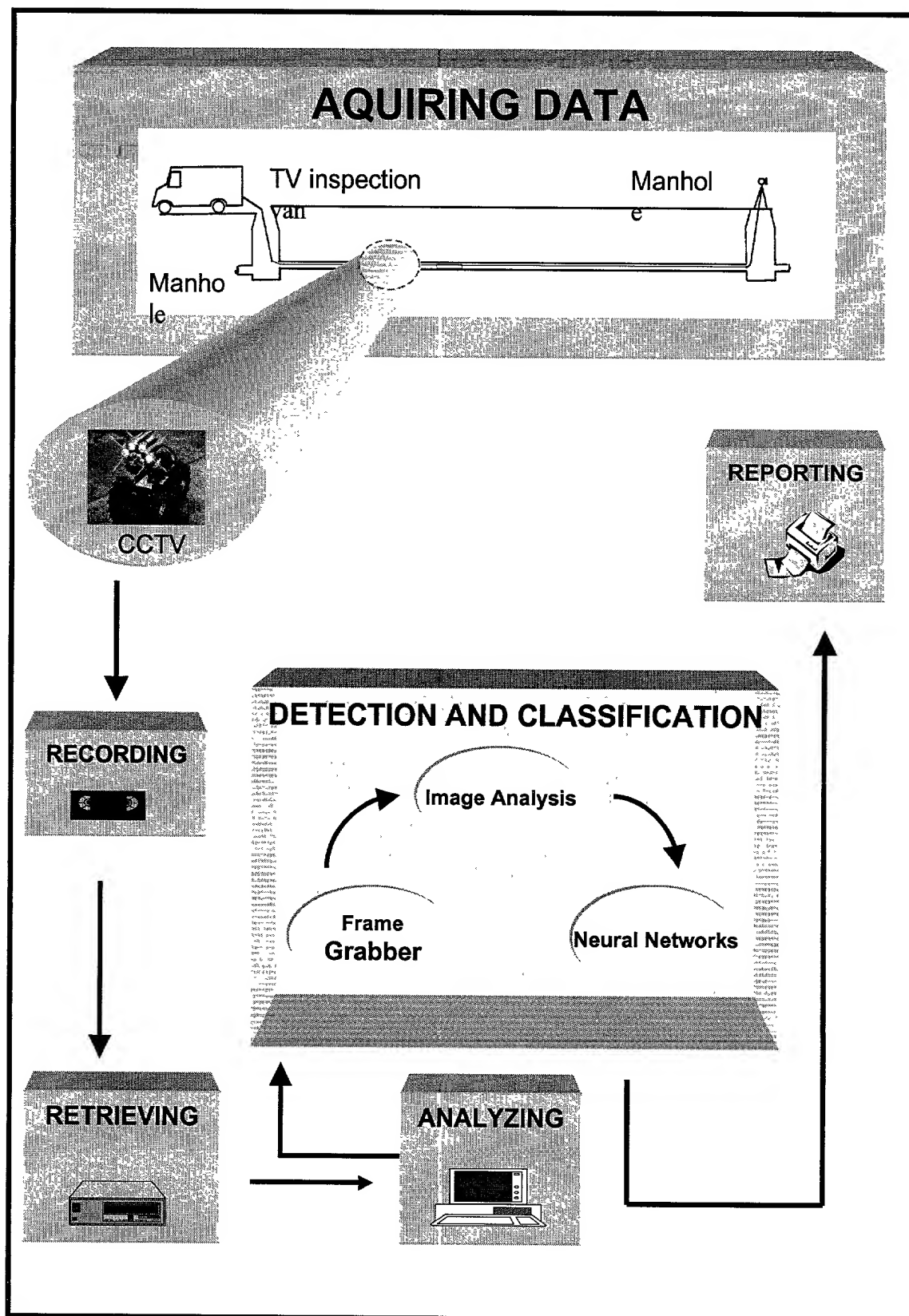


Figure 7: Proposed Automated Detection and Classification System

Figure 8: Methodology for Developing Automated Detection System

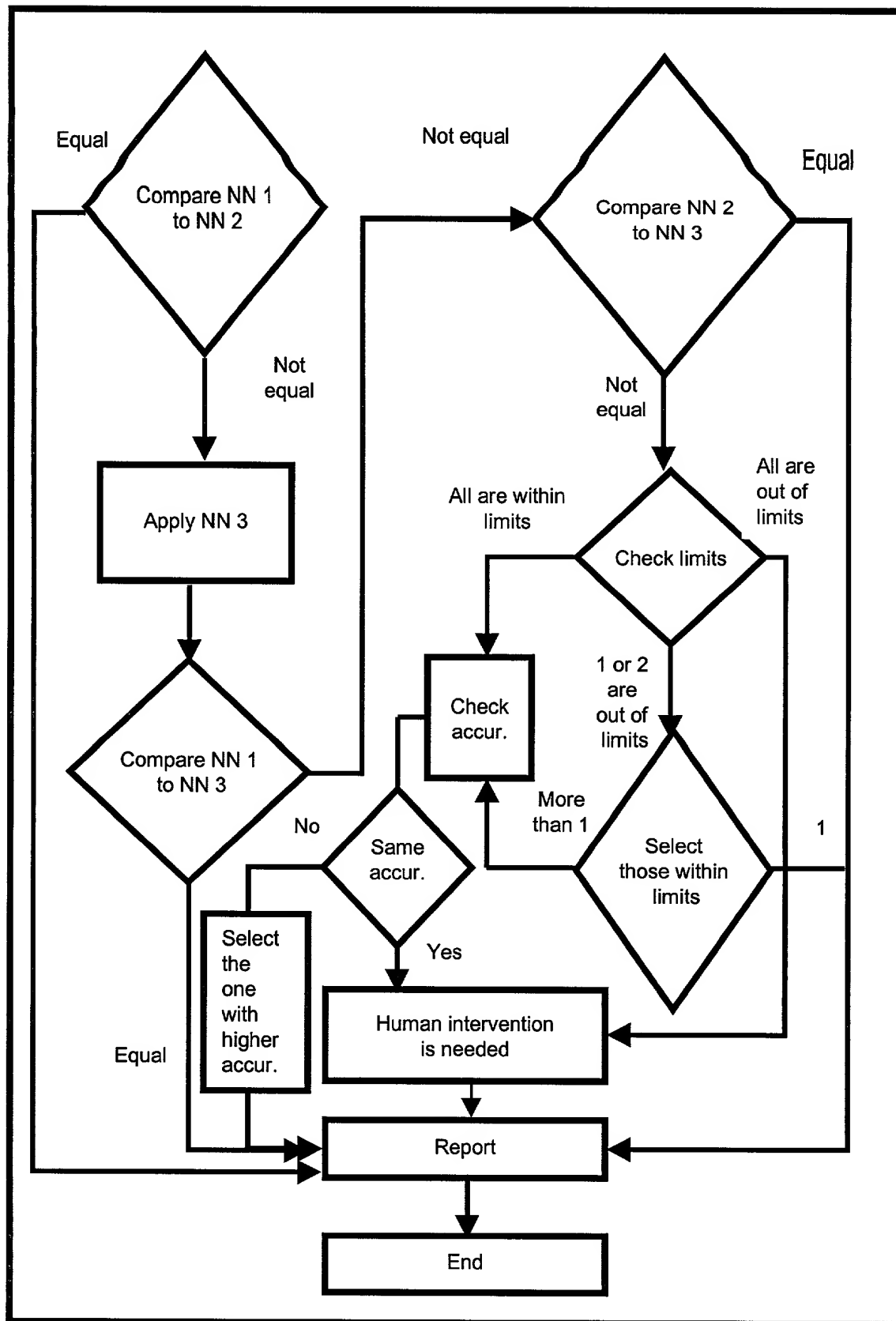


Figure 9: Algorithm of the Multiple Classifier System

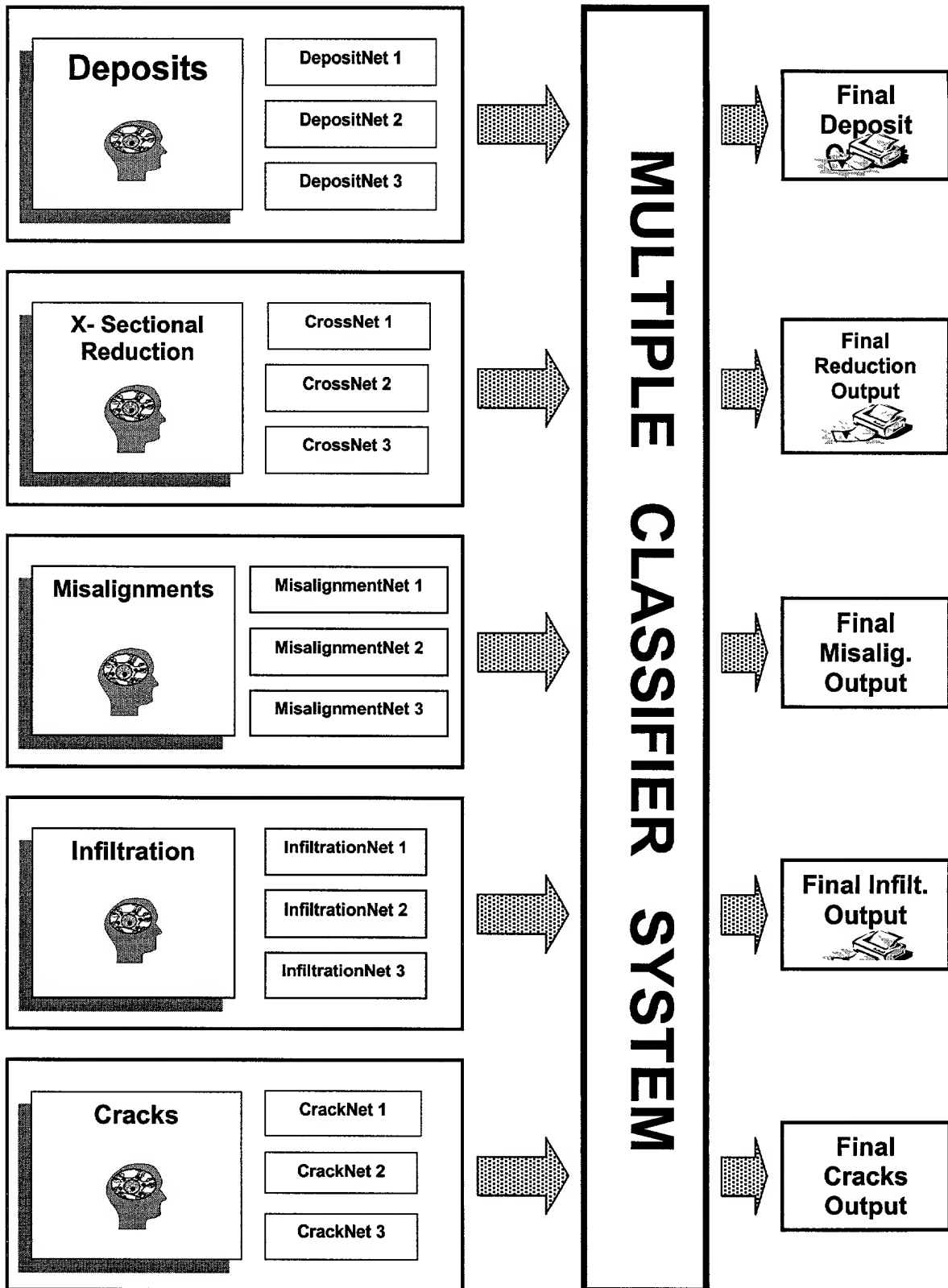


Figure 3-10: Utilization of the Multiple Classifier System

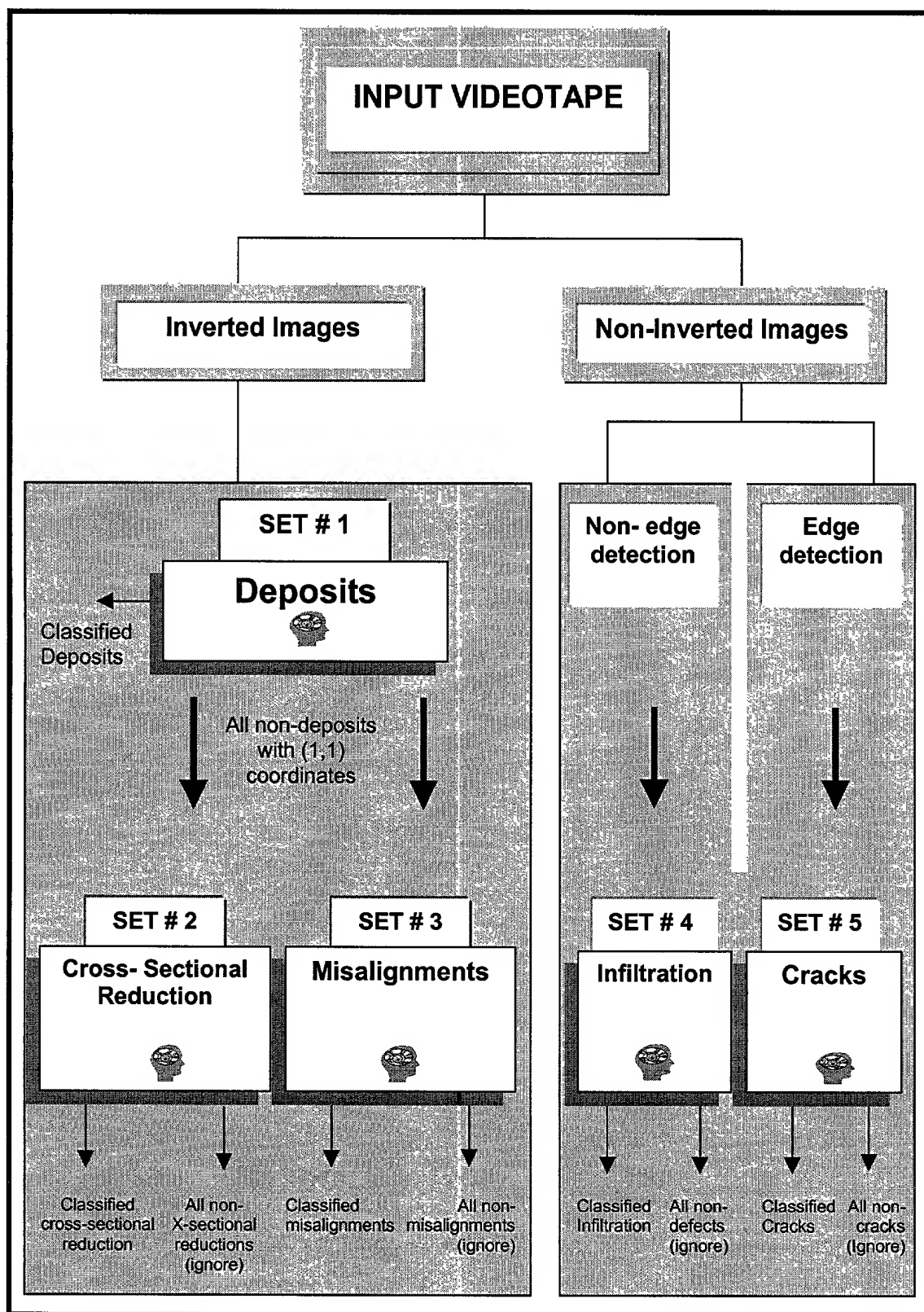


Figure 3-11: Solution Strategy

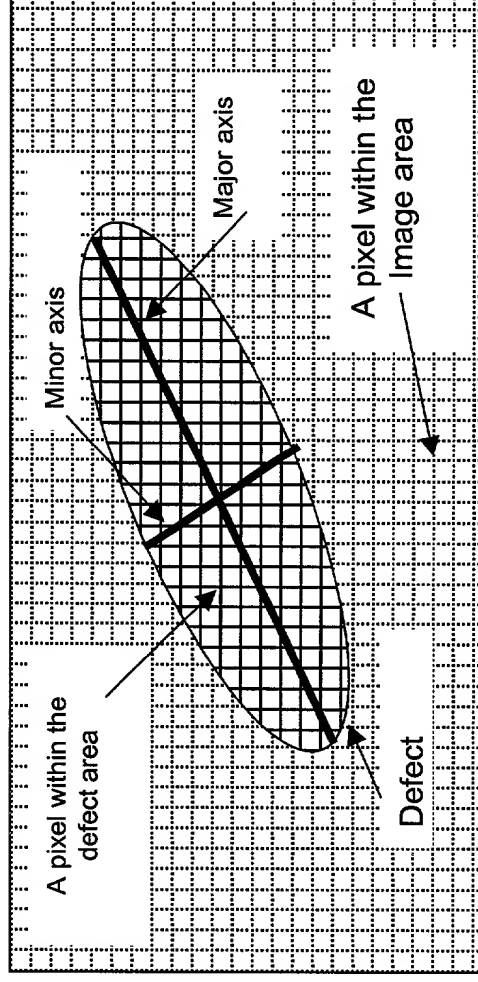


Figure 12: Geometrical Attributes of Defects

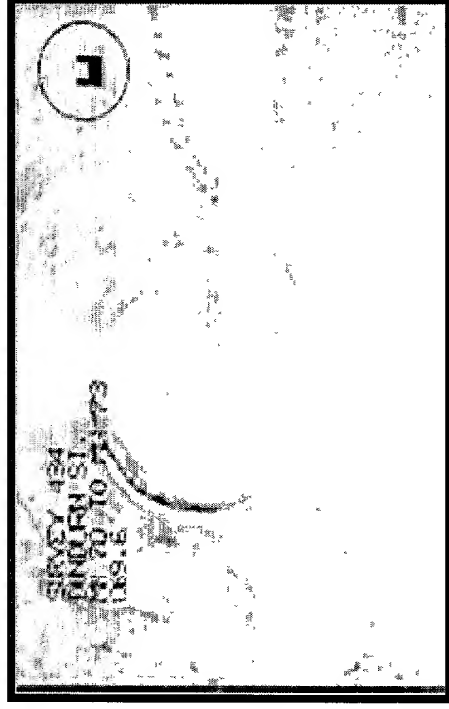


Figure 13: Background Subtracted Image of Cracks



Figure 15: Dilated Image of Cracks

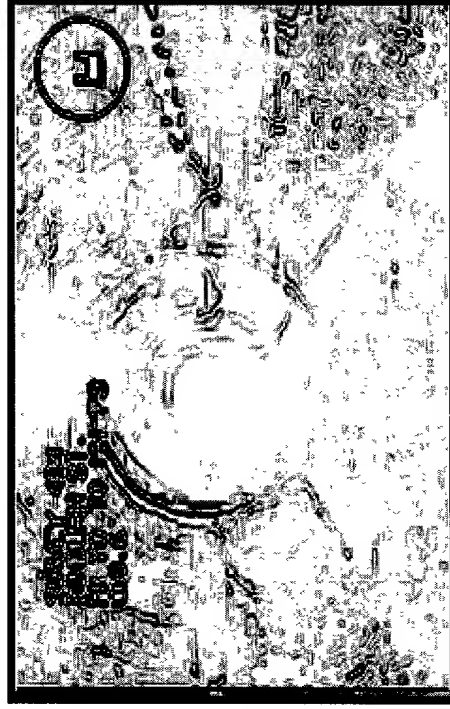


Figure 14: Edge Detected Image of Cracks



Figure 16: Thresholded Image of Cracks



Figure 17: Segmented Image of Cracks

Results							
	Area	Mean	S.D.	X	Y	Length	Major
1.	10298.00	190.81	66.39	53.65	71.71	1524.50	158.94
2.	243.00	128.24	43.82	219.07	7.41	104.81	28.39
3.	136.00	111.10	21.24	244.56	4.30	65.70	17.86
4.	2159.00	188.20	70.57	282.51	35.62	368.13	61.65
5.	292.00	131.72	32.81	202.45	17.68	89.01	31.38
6.	192.00	109.64	23.06	202.17	51.82	118.71	24.13
7.	241.00	130.94	42.37	178.54	59.96	101.64	23.34
8.	1345.00	168.22	65.38	259.09	87.75	399.50	95.43
9.	185.00	140.76	49.97	205.39	84.36	68.87	17.46
10.	356.00	143.16	44.28	176.45	103.95	96.43	29.89
11.	177.00	137.53	39.02	201.72	105.62	56.63	18.03
12.	591.00	142.98	50.42	37.24	123.74	175.10	51.35
13.	4009.00	145.72	47.18	281.45	174.64	761.11	88.82
14.	251.00	136.23	42.46	186.72	144.71	90.08	30.47
15.	136.00	119.99	31.48	88.65	158.98	59.84	22.41

Figure 18: Analysis Results of an Image Depicting Cracks

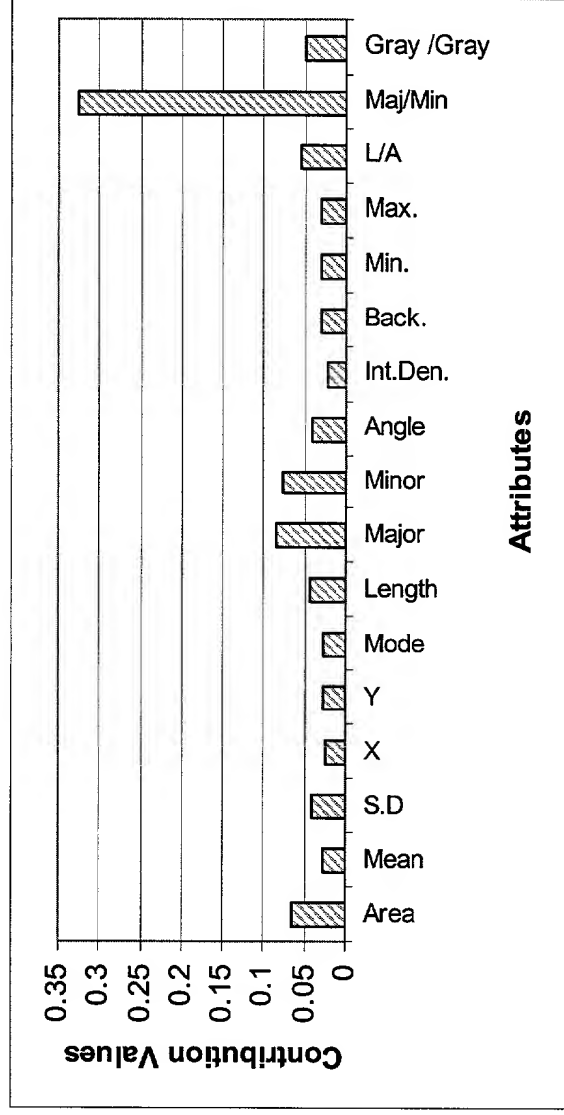


Figure 19: Contribution Values of Attributes Utilized in Designing the Preliminary Neural Network for Classification of Cracks

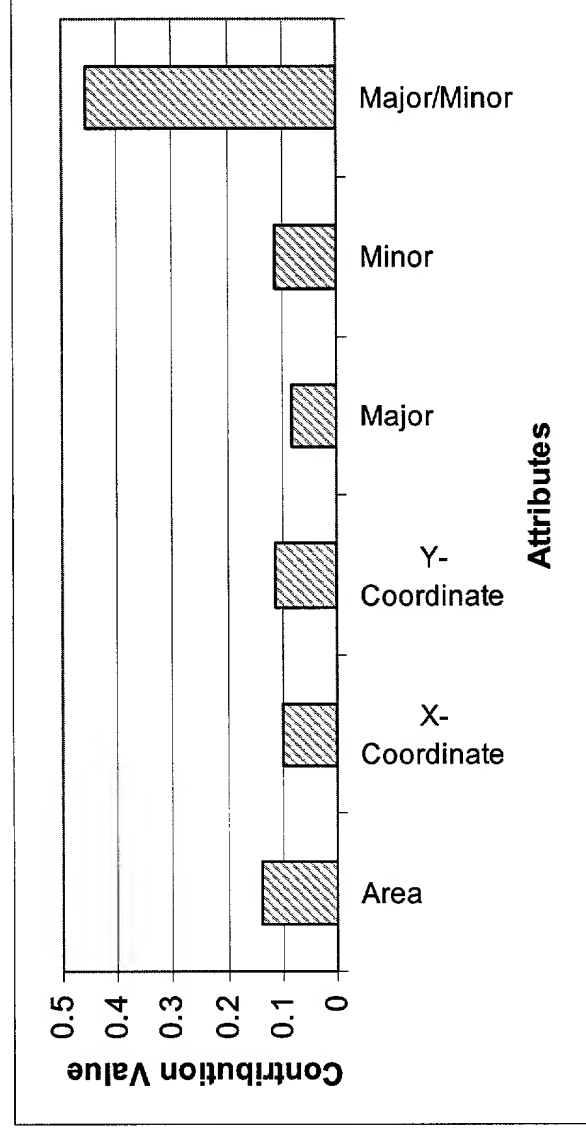


Figure 20: Contribution Values of Attributes Utilized in Designing Neural Network # 1 for Classification of Cracks

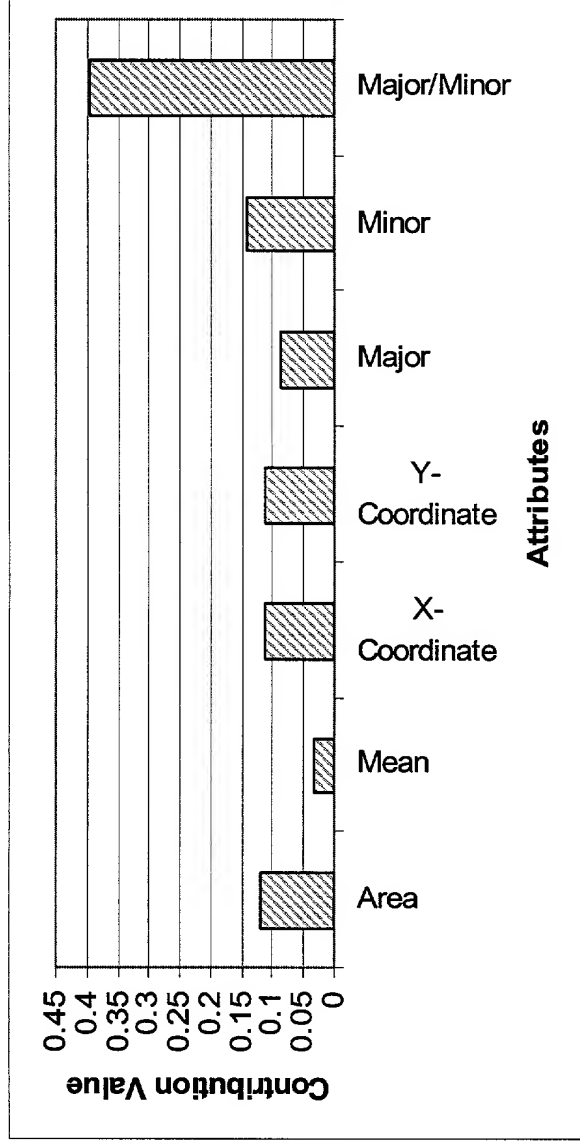


Figure 21: Contribution Values for the Selected Attributes Utilized in Designing CrackNet 2

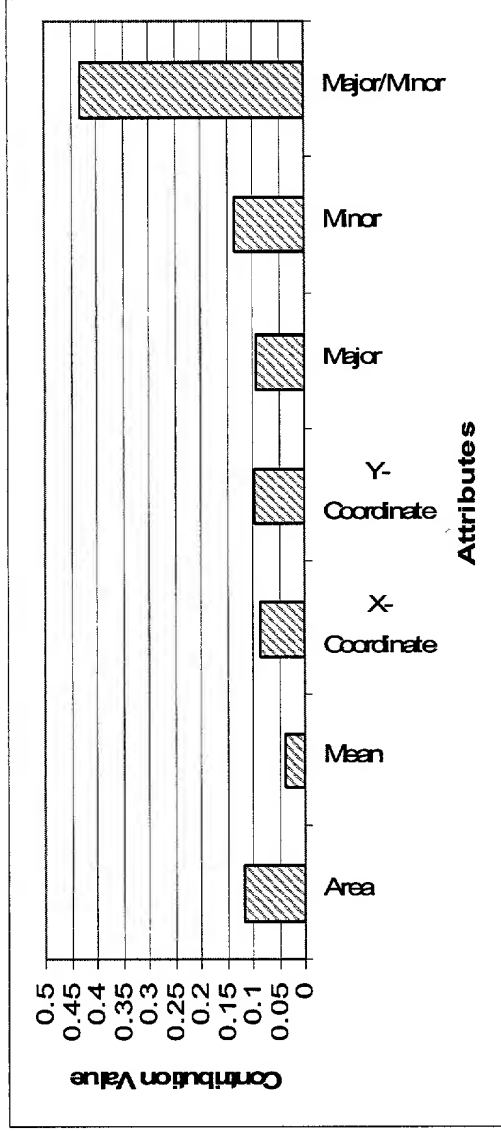


Figure 22: Contribution Values for the Selected Attributes Utilized in Designing CrackNet 3



Figure 23: Segmented Image of a Case Example on Cracks

File Edit Format Help						
Number of row with variable names (blank if none):						
First row containing actual training data:						
Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.						
	D	E	F	G		
2	0.035929877311	0.968737125397				
3	0.114000715315	0.886296689510				
4	0.000000000000	1.000000000000				
5	0.000000000000	1.000000000000				
6	0.100026234984	0.900299847126				
7	0.031811475754	0.968877077103				
8	0.000000000000	1.000000000000				
9	0.893140494823	0.104359865189				
10	0.019607180730	0.980554997921				
11	0.003982819617	0.989578843117				
12	0.005694665015	0.995122373104				
13	0.573563754559	0.428812980652				
14	0.044550366700	0.963026463985				
15	0.421342730522	0.578073859215				
16	0.706838846207	0.292702466249				
17						
18						

Figure 24: Output Results of a Case example on Cracks

File Edit Format Help

Number of row with variable names (blank if none):

First row containing actual training data:

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

☒ left/right arrow keys and edit

Size: 100 rows 20 columns

	D	E	F	G
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7	-----	Else		
8	-----	Else		
9	Crack			
10	-----	Else		
11	-----	Else		
12	-----	Else		
13	Crack			
14	-----	Else		
15	-----	Else		
16	Crack			
17	-----			
18	-----			

Figure 25: Thresholded Output Results of a Case example on Cracks

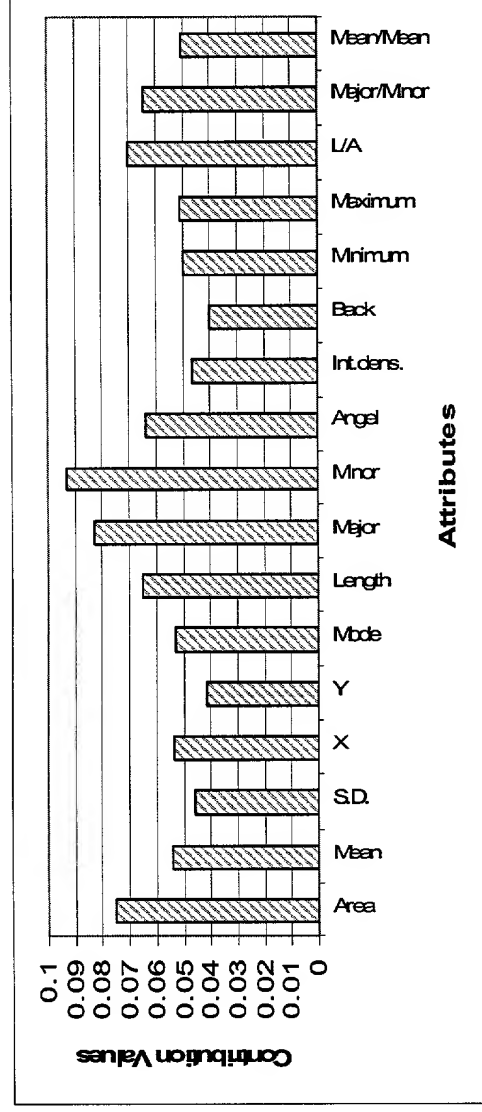


Figure 26: Contribution Values of Attributes Utilized in Designing InfiltrationNet 1

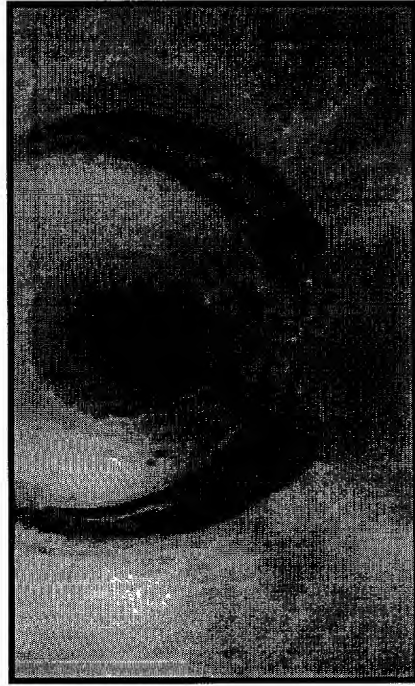


Figure 27: Dilated Image of Infiltration



Figure 29: Thresholded Image of Infiltration

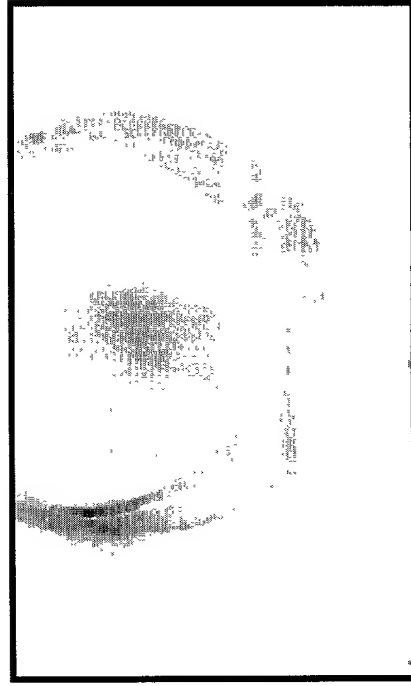


Figure 28: Background subtracted Image of Infiltration



Figure 30: Segmented Image of Infiltration

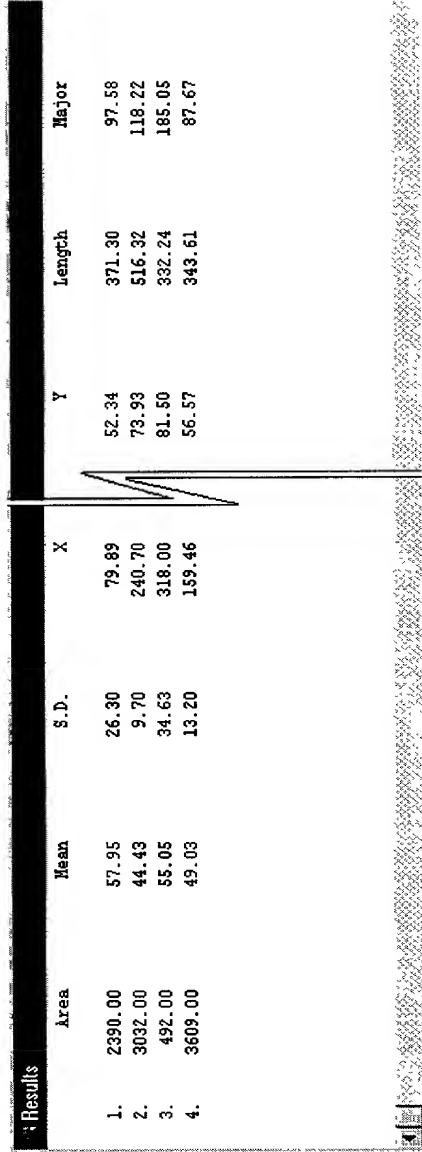


Figure 31: Analysis Results of an Image Depicting Infiltration

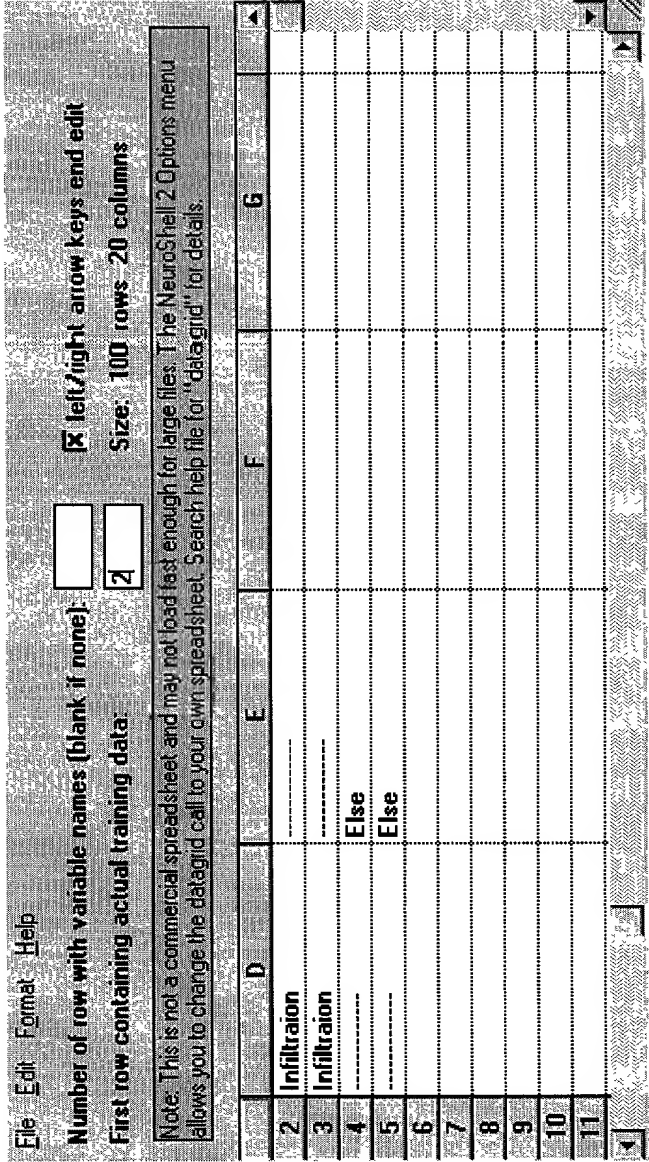


Figure 32: Classification Results of a Case Example on Infiltration

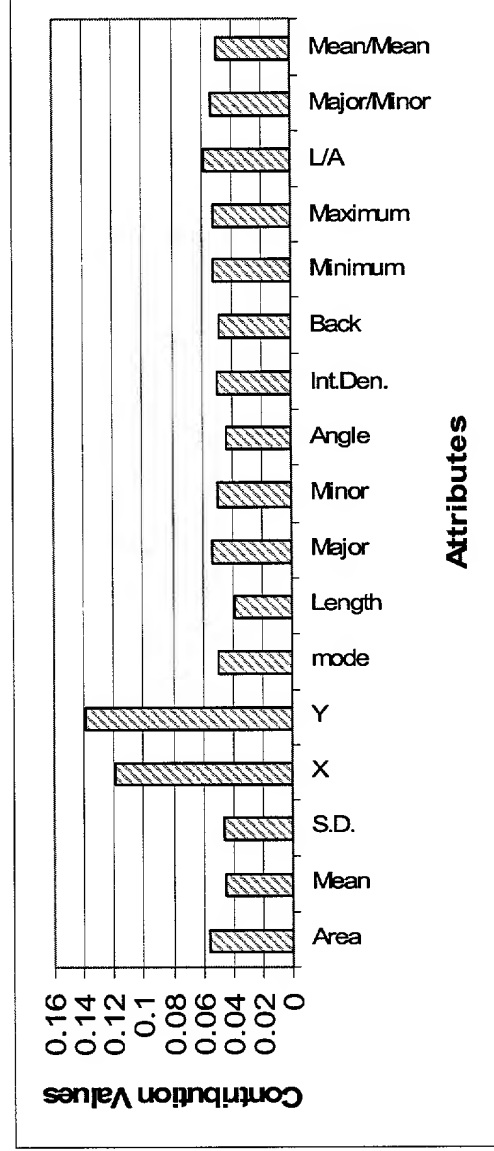


Figure 33: Contribution Values of Attributes Utilized in Designing DepositNet 1



Figure 34: Inverted Image of Deposits



Figure 35: Background Subtracted Image of Deposits

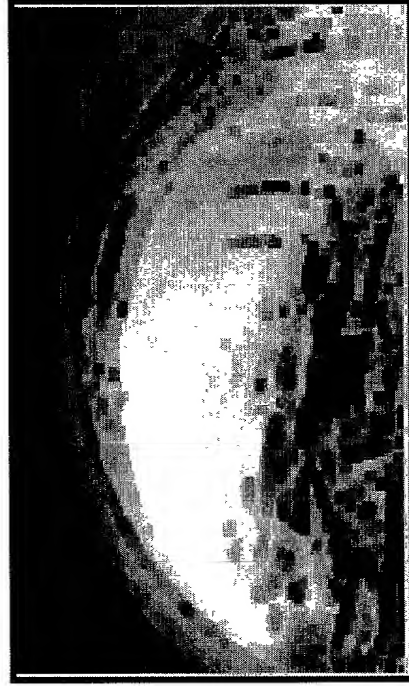


Figure 36: Dilated Image of Deposits



Figure 37: Thresholded Image of Deposits



Figure 38: Segmented Image of Deposits

Results					
	Area	Mean	S.D.	X	Y
1.	2652.00	80.03	22.30	55.52	37.85
2.	108.00	68.61	14.66	161.80	53.11
3.	144.00	71.94	16.32	175.35	66.67
4.	2972.00	96.81	34.10	69.02	114.82
					Length
					Major
					109.69
					17.59
					18.30
					98.21

Figure 39: Analysis Results of an Image Depicting Deposits

FileEditFormatHelp

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

2

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G
2	Else	-----		
3	Else	-----		
4	Else	-----		
5	-----	Deposits		
6				
7				
8				
9				
10				
11				
4				

Figure 40: Classification Results of a Case Example on Deposits

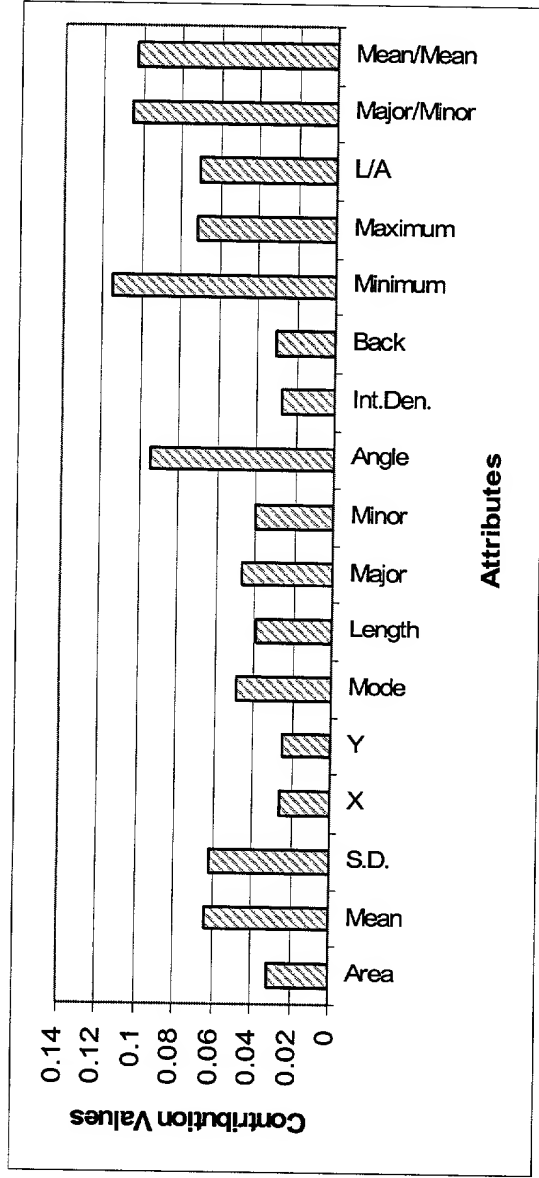


Figure 41: Contribution Values for all Attributes Utilized in Designing a Preliminary Neural Network for Classification of Cross-sectional Reductions



Figure 42: Inverted Image of cross-sectional Reductions



Figure 43: Dilated Image of cross-sectional Reductions

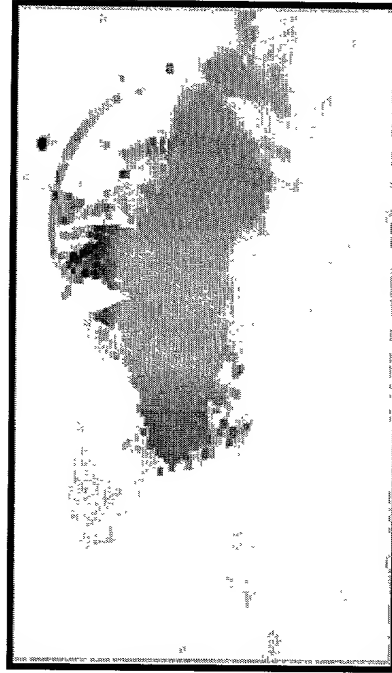


Figure 44: Background subtracted Image of Cross-sectional Reductions



Figure 45: Thresholded Image of Cross-sectional Reductions



Figure 46: Segmented Image of Cross-sectional Reductions

Results							
	Area	Mean	S.D.	X			
1.	76.00	90.84	55.80	256.92			
2.	17141.00	77.01	17.65	206.03			
3.	433.00	51.68	4.15	82.04			
4.	63.00	49.22	2.34	70.62			
5.	105.00	53.85	6.10	6.34			
					Y		
					length		
					Major		
					16.22	38.04	12.60
					102.46	1347.63	196.15
					47.86	149.88	32.95
					47.83	36.38	13.25
					162.71	45.56	15.40

Figure 47: Analysis Results of an Image Depicting Cross-sectional Reductions

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Number of row with variable names (blank if none):

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First row containing actual training data:

2

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for 'datagrid' for details.

	D	E	F	G
2	Cross-sectional reduction			
3				
4				
5				
6				
7				
8				
9				
10				
11				

Figure 48: Classification Results of a Case Example on Cross-sectional Reductions

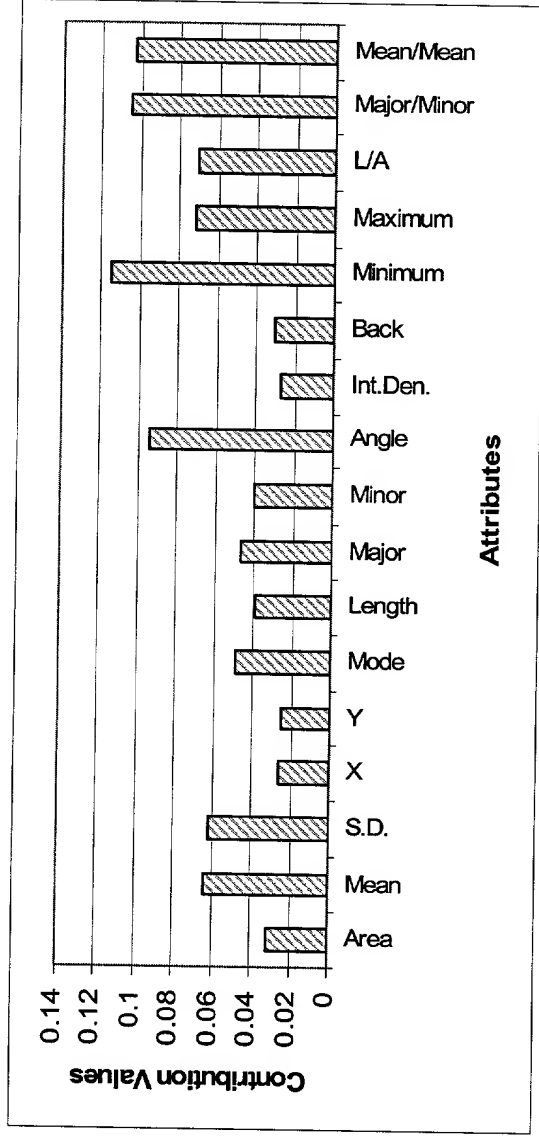


Table 49: Initial Parameters Used in Designing a Preliminary Neural Network for Classification of Misalignments

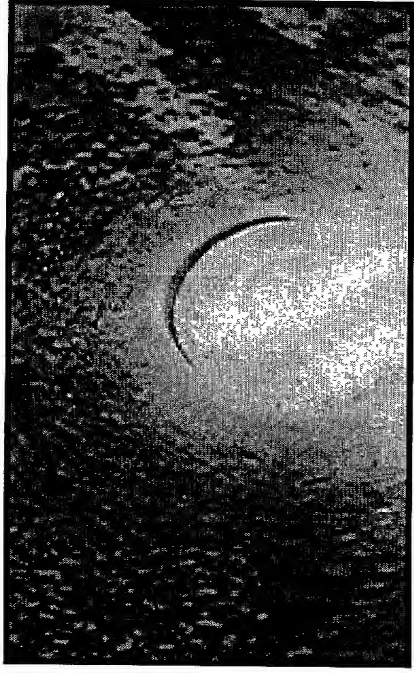


Figure 50: Inverted Image of Misalignments

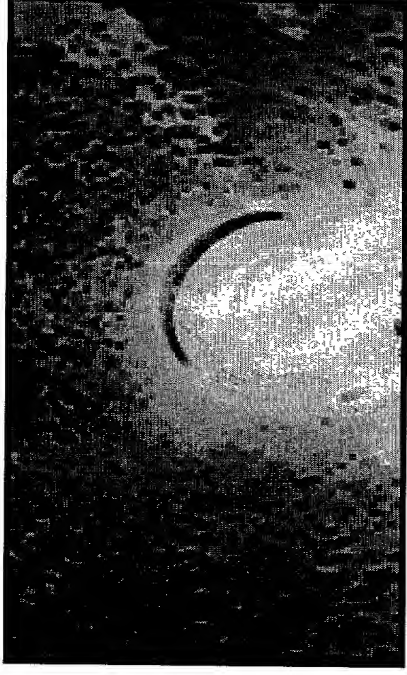


Figure 51: Dilated Image of Misalignments



Figure 52: Background Subtracted Image of Misalignments



Figure 53: Thresholded Image of Misalignments

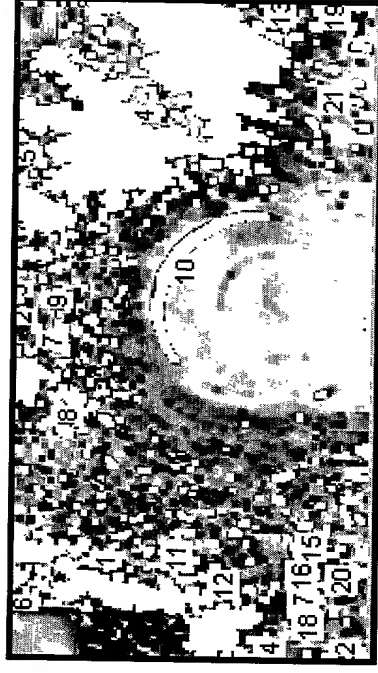


Figure 54: Segmented Image of Misalignments

Figure 55: Analysis Results of an Image Depicting Misalignments

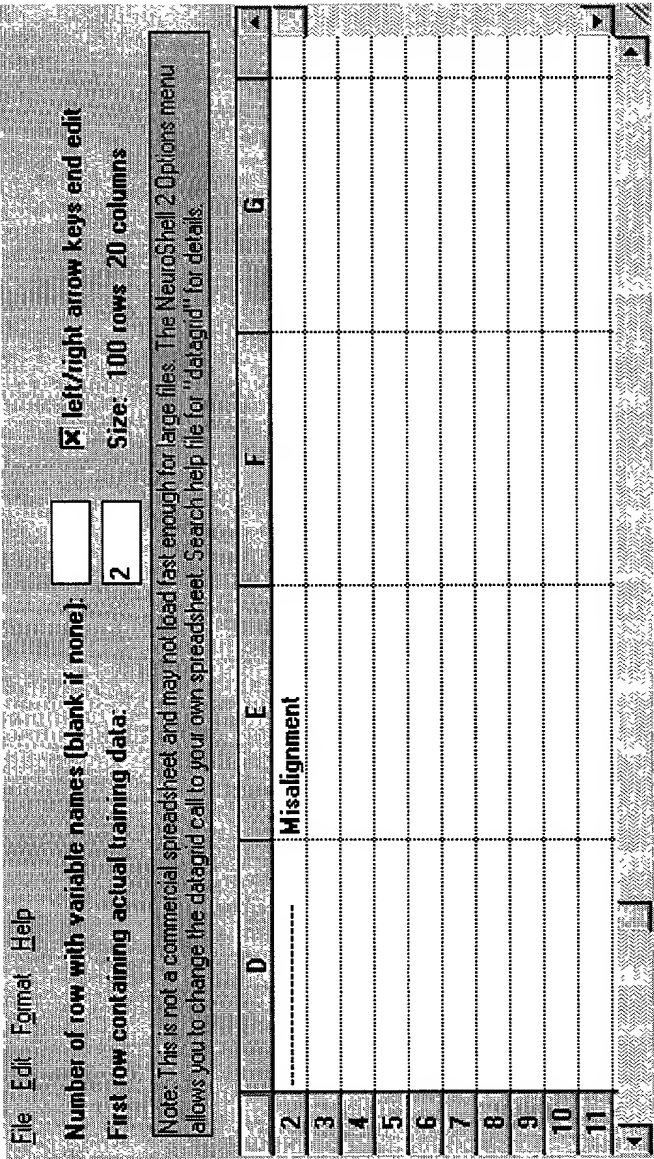


Figure 56: Classification Results of a Case example on Misalignments



Figure 57: Segmented Image of Deposits

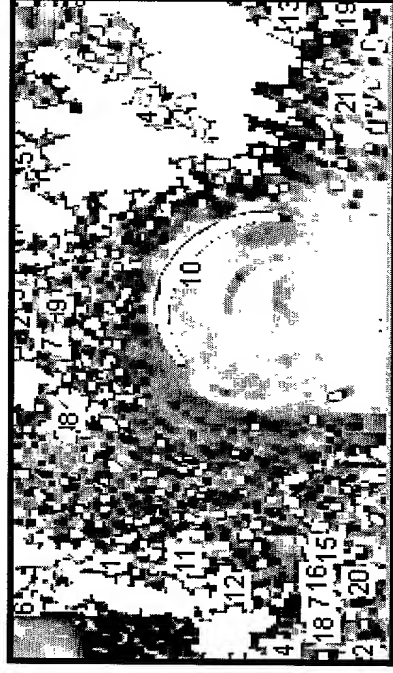


Figure 58: Segmented image of Misalignments

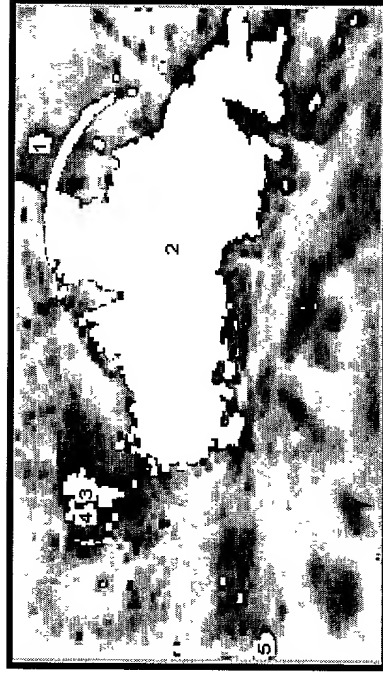


Figure 59: Segmented Image of Cross-sectional Reductions



Figure 60: Segmented Image of Cracks

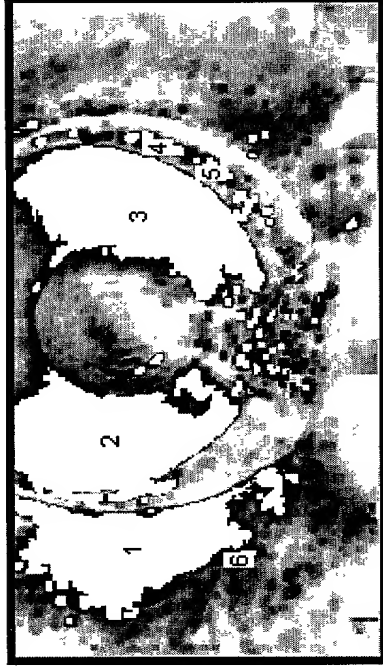


Figure 61: Segmented Image of Infiltration

File

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Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

1

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu 'datagrid' for details.

	D	E	F	G
1	Else	-----		
2	Else	-----		
3	Else	-----		
4	-----	Deposits		
5				
6				
7	Else	-----		
8	Else	-----		
9	Else	-----		
10	Else	-----		
11	Else	-----		
12	Else	-----		
13	Else	-----		
14	Else	-----		
15	Else	-----		
16	Else	-----		
17	Else	-----		
18	Else	-----		
19	Else	-----		
20	Else	-----		
21	Else	-----		
22	Else	-----		
23	Else	-----		
24	Else	-----		
25	Else	-----		
26	Else	-----		
27	Else	-----		
28	Else	-----		
29				
30				

Figure 62: Output Results of a Case Example on Deposits Utilizing DepositNet 1 and the Solution Strategy Module

	D	E	F	G
31	Else	-----		
32	Else	-----		
33	Else	-----		
34	Else	-----		
35	Else	-----		
36				
37				
38	Else	-----		
39	Else	-----		
40	Else	-----		
41	Else	-----		
42	Else	-----		
43	Else	-----		
44	Else	-----		
45	Else	-----		
46	Else	-----		
47	Else	-----		
48	Else	-----		
49	Else	-----		
50	Else	-----		
51	Else	-----		
52				
53				
54	Else	-----		
55	Else	-----		
56	Else	-----		
57	Else	-----		
58	Else	-----		
59	Else	-----		
60				
61				

Figure 62: Output Results of a Case Example on Deposits Utilizing DepositNet 1 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	Else	-----		
2	Else	-----		
3	Else	-----		
4	-----	Deposits		
5				
6				
7	Else	-----		
8	Else	-----		
9	Else	-----		
10	Else	-----		
11	Else	-----		
12	Else	-----		
13	Else	-----		
14	Else	-----		
15	Else	-----		
16	Else	-----		
17	Else	-----		
18	Else	-----		
19	Else	-----		
20	Else	-----		
21	Else	-----		
22	Else	-----		
23	Else	-----		
24	Else	-----		
25	Else	-----		
26	Else	-----		
27	Else	-----		
28	Else	-----		
29				

Figure 63: Output Results of a Case Example on Deposits Utilizing DepositNet 2 and the Solution Strategy Module

	D	E	F	G
30				
31	Else			
32	Else			
33	Else			
34	Else			
35	Else			
36				
37				
38	Else			
39	Else			
40	Else			
41	Else			
42	Else			
43	Else			
44	Else			
45	Else			
46	Else			
47	Else			
48	Else			
49	Else			
50	Else			
51	Else			
52				
53				
54	Else			
55	Else			
56	Else			
57	Else			
58	Else			
59	Else			
60				

Figure 63: Output Results of a Case Example on Deposits Utilizing DepositNet 2 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	Else	-----		
2	Else	-----		
3	Else	-----		
4		Deposits		
5				
6				
7	Else	-----		
8	Else	-----		
9	Else	-----		
10	Else	-----		
11	Else	-----		
12	Else	-----		
13	Else	-----		
14	Else	-----		
15	Else	-----		
16	Else	-----		
17	Else	-----		
18	Else	-----		
19	Else	-----		
20	Else	-----		
21	Else	-----		
22	Else	-----		
23	Else	-----		
24	Else	-----		
25	Else	-----		
26	Else	-----		
27	Else	-----		
28	Else	-----		

Figure 64: Output Results of a Case Example on Deposits Utilizing DepositNet 3 and the Solution Strategy Module

	D	E	F	G
29				
30				
31	Else	-----		
32	Else	-----		
33	Else	-----		
34	Else	-----		
35	Else	-----		
36				
37				
38	Else	-----		
39	Else	-----		
40	Else	-----		
41	Else	-----		
42	Else	-----		
43	Else	-----		
44	Else	-----		
45	Else	-----		
46	Else	-----		
47	Else	-----		
48	Else	-----		
49	Else	-----		
50	Else	-----		
51	Else	-----		
52				
53				
54	Else	-----		
55	Else	-----		
56	Else	-----		
57	Else	-----		
58	Else	-----		
59	Else	-----		

Figure 64: Output Results of a Case Example on Deposits Utilizing DepositNet 3 and the Solution Strategy Module (Continued)

	AA	AB	AC	AD	AE	AF	AG	AH
1					Else			
2					Else			
3					Else			
4					Deposits			
5								
6								
7					Else			
8					Else			
9					Else			
10					Else			
11					Else			
12					Else			
13					Else			
14					Else			
15					Else			
16					Else			
17					Else			
18					Else			
19					Else			
20					Else			
21					Else			
22					Else			
23					Else			
24					Else			
25					Else			
26					Else			
27					Else			
28					Else			

Figure 65: Comparison of Output Results of DepositNet 1-3 Utilizing the Multiple Classifier Module

	AA	AB	AC	AD	AE	AF	AG	AH
31					Else			
32					Else			
33					Else			
34					Else			
35					Else			
36								
37								
38					Else			
39					Else			
40					Else			
41					Else			
42					Else			
43					Else			
44					Else			
45					Else			
46					Else			
47					Else			
48					Else			
49					Else			
50					Else			
51					Else			
52								
53								
54					Else			
55					Else			
56					Else			
57					Else			
58					Else			
59					Else			

Figure 65: Comparison of Output Results of DepositNet 1-3 Utilizing the Multiple Classifier Module (Continued)

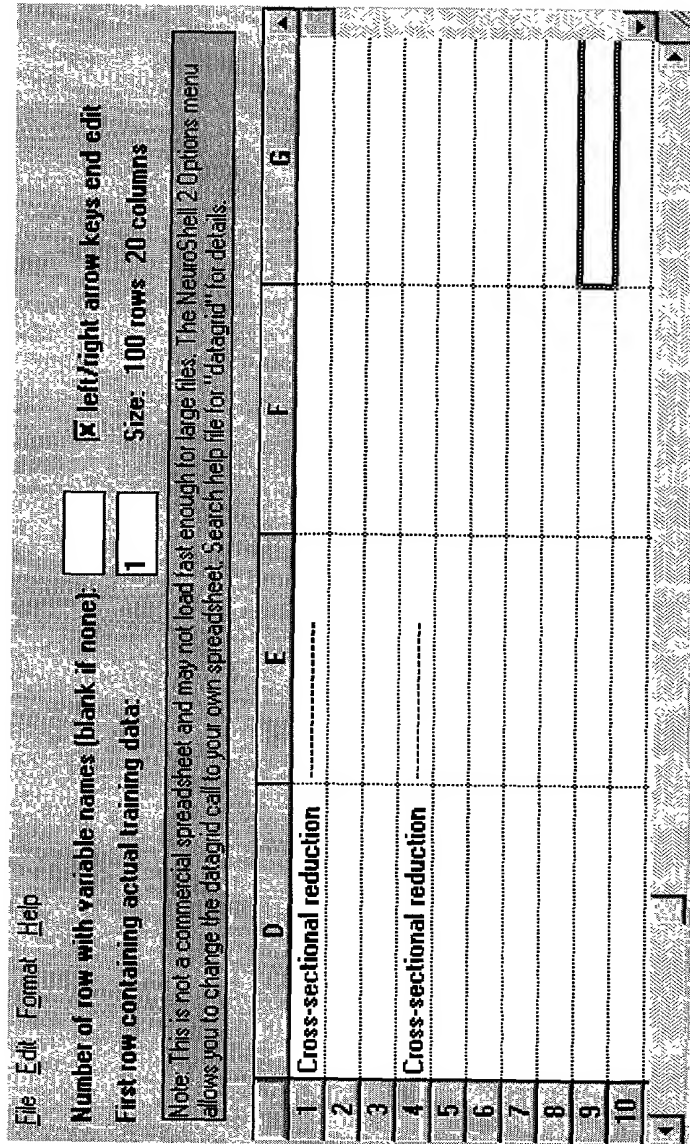


Figure 66: Output Results of a Case Example on Cross-sectional Reductions Utilizing CrossNet 1 and the Solution Strategy

FileEditFormatHelp

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

1

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G
1	-----	Else		
2				
3				
4	Cross-sectional reduction	-----		
5				
6				
7				
8				
9				
10				

Figure 67: Output Results of a Case Example on Cross-sectional Reductions Utilizing CrossNet 2 and the Solution Strategy

File Edit Format Help

Number of row with variable names (blank if none): ☒ left/right arrow keys end edit

First row containing actual training data: Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G
1	-----	Else		
2				
3				
4	Cross-sectional reductions	-----		
5				
6				
7				
8				
9				
10				

Figure 68: Output Results of a Case Example on Cross-sectional Reductions Utilizing CrossNet 3 and the Solution Strategy Module

	AC	AD	AE	AF	AG	AJ	AK	AL	AM
1		equal						Else	
2									
3									
4			Cross-sectional reductions						
5									
6									
7									
8									
9									
10									

Figure 69: Comparison of Output Results of CrossNet 1-3 Utilizing the Multiple Classifier Module

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G	
1	-----	Misalignment			
2					
3					
4	Else	-----			
5					
6					
7					
8					
9					
10					

Figure 70: Output Results of a Case Example on Misalignments Utilizing MisalignmentNet 1 and the Solution Strategy Module

File

Edit

Format

Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

1

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G	H
1	-----	Misalignment			
2					
3					
4	Else	-----			
5					
6					
7					
8					
9					
10					
11					

Figure 71: Output Results of a Case Example on Misalignments Utilizing MisalignmentNet 2 and the Solution Strategy Module

File Edit Format Help

Number of row with variable names (blank if none): ☒ left/right arrow keys end edit

First row containing actual training data: Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu allows you to change the datagrid call to your own spreadsheet. Search help file for "datagrid" for details.

	D	E	F	G	
1	-----	Misalignment			
2					
3					
4	-----	-----			
5					
6					
7					
8					
9					
10					

Figure 72: Output Results of a Case Example on Misalignments Utilizing MisalignmentNet 3 and the Solution Strategy

	AA	AB	AC	AD	AE	AF	AG
1	Misalignment						
2							
3							
4	equal			Else			
5							
6							
7							
8							
9							
10							

Figure 73: Comparison of Output Results of MisalignmentNet 1-3 Utilizing the Multiple Classifier Module



Figure 74: Segmented Image of Cracks

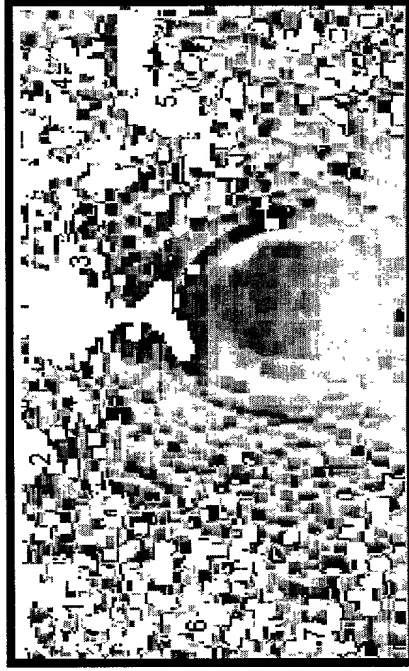


Figure 76: Segmented Image of Misalignments



Figure 75: Segmented Image of Cross-sectional Reductions



Figure 77: Segmented image of Deposits

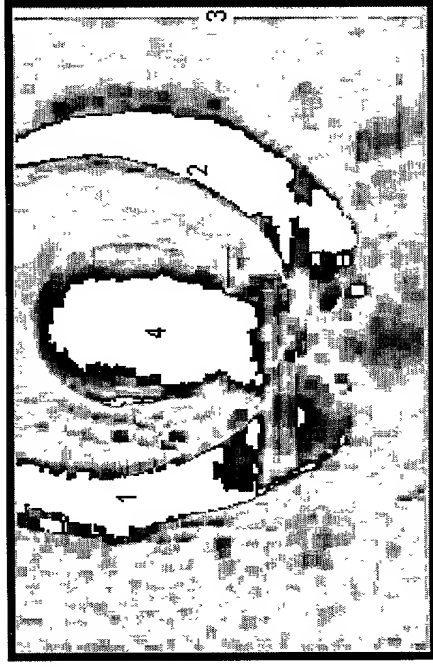


Figure 78: Segmented Image of Infiltration

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	-----	Else		
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7				
8				
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	-----	Else		
13	-----	Else		
14	-----	Else		
15	-----	Else		
16				
17				

Figure 79: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 1 and the Solution Strategy Module

	D	E	F	G
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		
22	Infiltration	-----		
23	-----	Else		
24	-----	Else		
25				
26				
27	-----	Else		
28	-----	Else		
29	-----	Else		
30				
31				
32	Infiltration	-----		
33	Infiltration	-----		
34	-----	Else		
35	-----	Else		
36				

Figure 79: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 1 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none): ☒ left/right arrow keys end edit

First row containing actual training data: Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	-----	Else		
2	-----	Else		
3	-----	Else		
4	Infiltration	-----		
5	-----	Else		
6	-----	Else		
7				
8				
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	-----	Else		
13	-----	Else		
14	-----	Else		
15	-----	Else		
16				

Figure 80: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 2 and the Solution Strategy Module

	D	E	F	G
17				
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		
22	-----	Else		
23	-----	Else		
24	-----	Else		
25				
26				
27	-----	Else		
28	Infiltration	-----		
29	-----	Else		
30				
31				
32	Infiltration	-----		
33	Infiltration	-----		
34	-----	Else		
35	-----	Else		
36				
37				

Figure 80: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 2 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	Infiltration	-----		
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7				
8				
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	-----	Else		
13	-----	Else		
14	-----	Else		
15	-----	Else		
16				
17				

Figure 81: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 3 and the Solution Strategy Module

	D	E	F	G
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		
22	-----	Else		
23	-----	Else		
24	-----	Else		
25				
26				
27	-----	Else		
28	-----	Else		
29	-----	Else		
30				
31				
32	Infiltration	-----		
33	Infiltration	-----		
34	-----	Else		
35	-----	Else		
36				
37				
38				

Figure 81: Output Results of a Case Example on Infiltration Utilizing InfiltrationNet 3 and the Solution Strategy Module (Continued)



Figure 83: Segmented Image of Cracks



Figure 84: Segmented Image of Cross-sectional Reductions

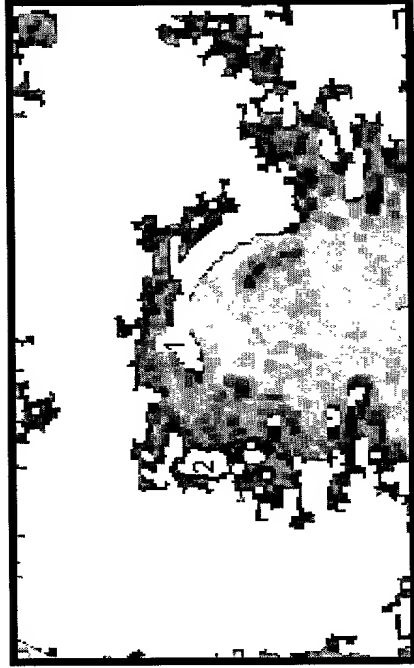


Figure 85: Segmented Image of Misalignments



Figure 86: Segmented Image of Deposits



Figure 87: Segmented Image of Infiltration

File Edit Format Help

Number of row with variable names (blank if none):

First row containing actual training data:

☒ left/right arrow keys end edit

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	-----	Else		
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7	-----	Else		
8	Crack	-----		
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	Crack	-----		
13	-----	Else		
14	-----	Else		
15	-----	Else		
16				
17				
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		
22				

Figure 88: Output Results of a Case Example on Cracks Utilizing CrackNet 1 and the Solution Strategy Module

	D	E	F	G
23				
24	-----	Else		
25	-----	Else		
26				
27				
28	Crack	-----		
29	-----	Else		
30				
31				
32	-----	Else		
33	Crack	-----		
34	-----	Else		
35	-----	Else		
36	-----	Else		
37	-----	Else		
38	-----	Else		
39	-----	Else		
40	-----	Else		
41				
42				
43				

Figure 88: Output Results of a Case Example on Cracks Utilizing CrackNet 1 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none):

☒ left/right arrow keys end edit

First row containing actual training data:

Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	-----	Else		
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7	-----	Else		
8	Crack	-----		
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	Crack	-----		
13	-----	Else		
14	-----	Else		
15	Crack	-----		
16				
17				
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		
22				
23				

Figure 89: Output Results of a Case Example on Cracks Utilizing CrackNet 2 and the Solution Strategy Module

	D	E	F	G
24	Crack	-----		
25	-----	Else		
26				
27				
28	-----	Else		
29	-----	Else		
30				
31				
32	-----	Else		
33	Crack	-----		
34	-----	Else		
35	-----	Else		
36	-----	Else		
37	-----	Else		
38	-----	Else		
39	-----	Else		
40	-----	Else		
41				
42				

Figure 89: Output Results of a Case Example on Cracks Utilizing CrackNet 2 and the Solution Strategy Module (Continued)

File Edit Format Help

Number of row with variable names (blank if none): ☒ left/right arrow keys end edit

First row containing actual training data: Size: 100 rows 20 columns

Note: This is not a commercial spreadsheet and may not load fast enough for large files. The NeuroShell 2 Options menu "datagrid" for details.

	D	E	F	G
1	-----	Else		
2	-----	Else		
3	-----	Else		
4	-----	Else		
5	-----	Else		
6	-----	Else		
7	-----	Else		
8	Crack	-----		
9	-----	Else		
10	-----	Else		
11	-----	Else		
12	Crack	-----		
13	-----	Else		
14	-----	Else		
15	Crack	-----		
16				
17				
18	-----	Else		
19	-----	Else		
20	-----	Else		
21	-----	Else		

Figure 90: Output Results of a Case Example on Cracks Utilizing CrackNet 3 and the Solution Strategy Module

	D	E	F	G
22				
23				
24	-----	Else		
25	-----	Else		
26				
27				
28	-----	Else		
29	-----	Else		
30				
31				
32	-----	Else		
33	Crack	-----		
34	-----	Else		
35	-----	Else		
36	-----	Else		
37	-----	Else		
38	-----	Else		
39	-----	Else		
40	-----	Else		
41				
42				

Figure 90: Output Results of a Case Example on Cracks Utilizing CrackNet 3 and the Solution Strategy Module (Continued)

	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1				Else							
2				Else							
3				Else							
4				Else							
5				Else							
6				Else							
7				Else							
8				Crack							
9				Else							
10				Else							
11				Else							
12				Crack							
13				Else							
14				Else							
15		equal								Crack	
16											
17											
18				Else							
19				Else							
20				Else							
21				Else							
22											

Figure 91: Comparison of Output Results of CrackNet 1-3 Utilizing the Multiple Classifier Module

	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
23											
24			equal				Else				
25				Else							
26											
27											
28			equal								Else
29				Else							
30											
31											
32				Else							
33				Crack							
34				Else							
35				Else							
36				Else							
37				Else							
38				Else							
39				Else							
40				Else							
41											

Figure 91: Comparison of Output Results of CrackNet 1-3 Utilizing the Multiple Classifier Module (Continued)

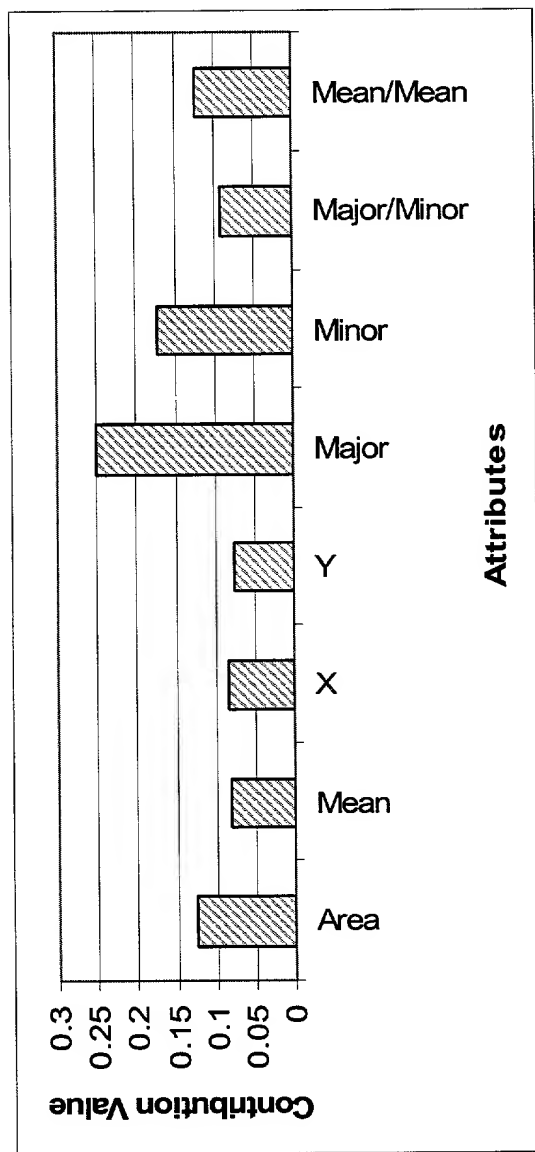


Figure 108: Contribution Values of Attributes Utilized in Designing InfiltrationNet 2

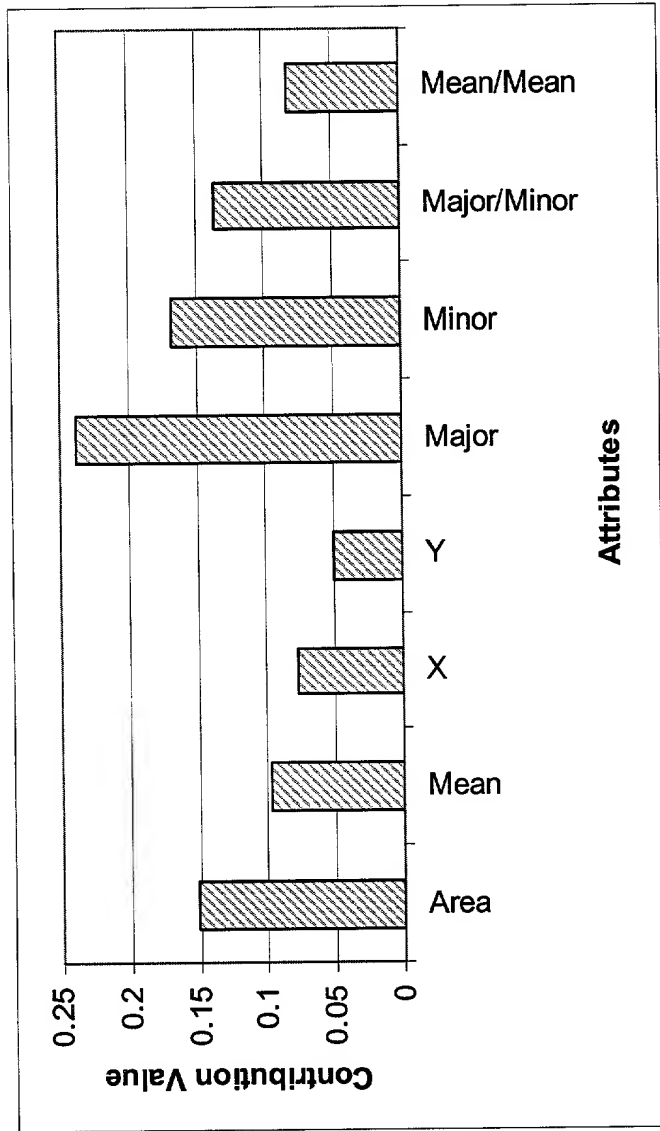


Figure 109: Contribution Values of Attributes Utilized in Designing InfiltrationNet 3

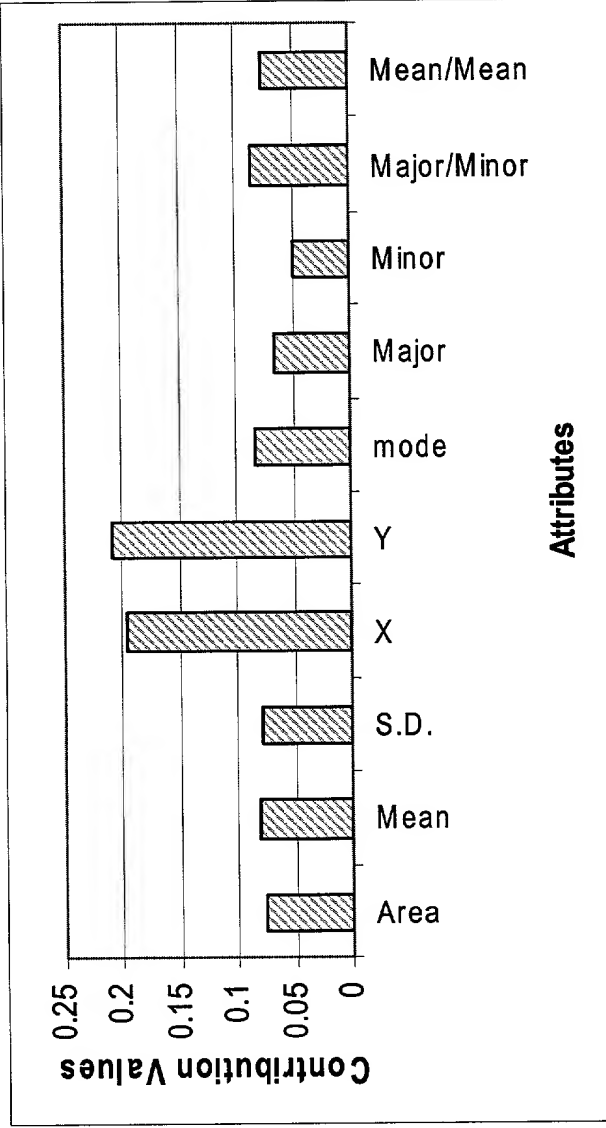


Figure 110: Contribution Values of Attributes Utilized in Designing DepositNet 2

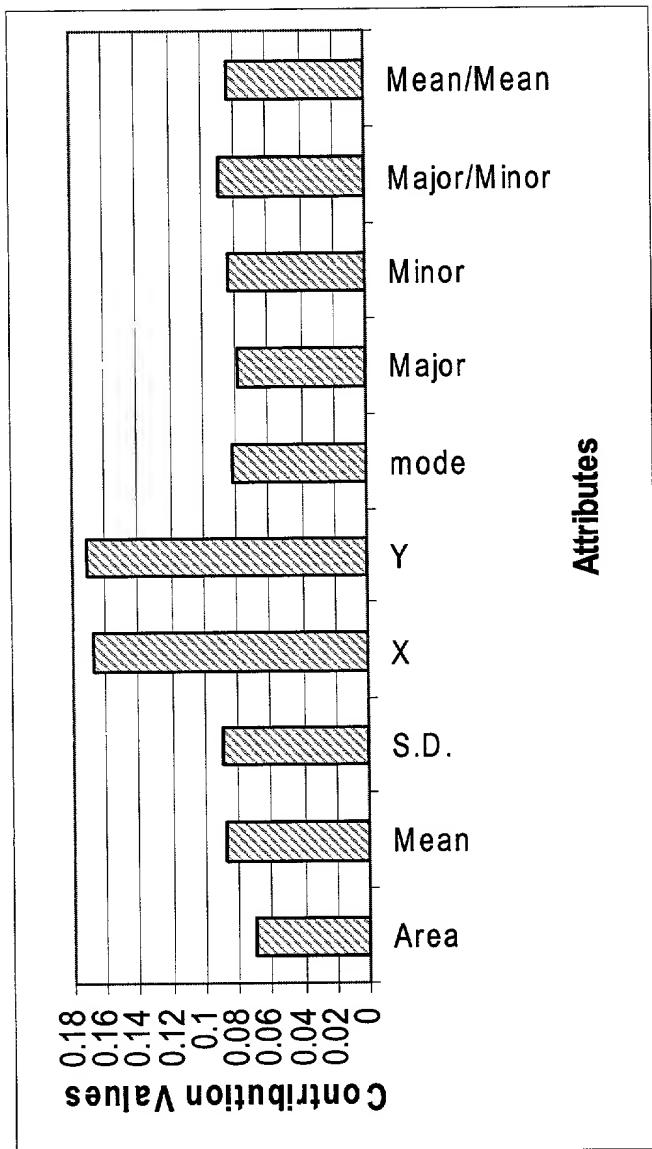


Figure 111: Contribution Values of Attributes Utilized in Designing DepositNet 3

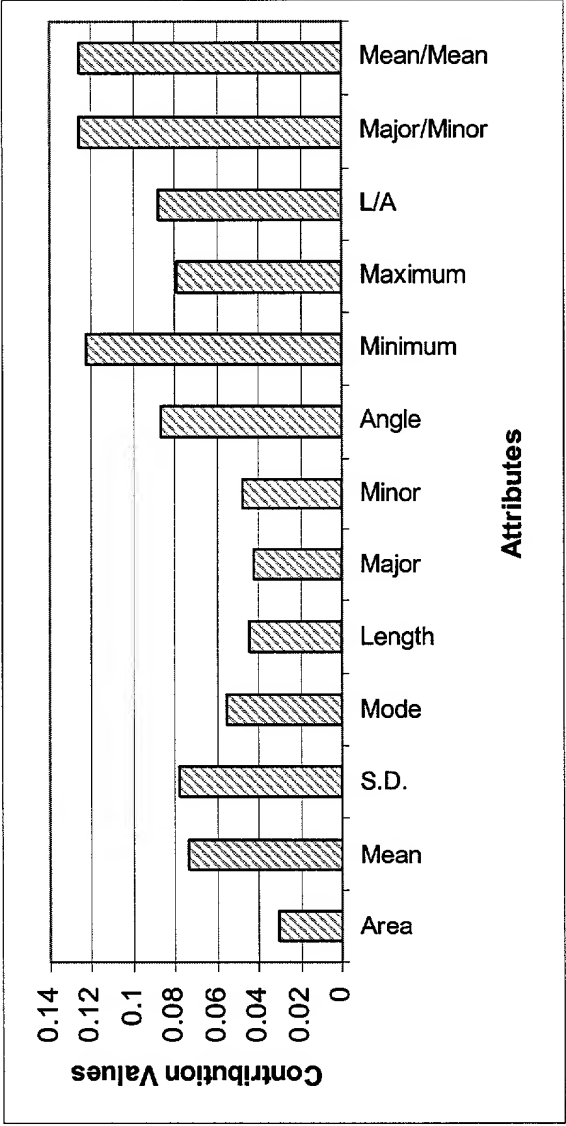


Figure 112: Contribution Values of Attributes Utilized in Designing CrossNet 1

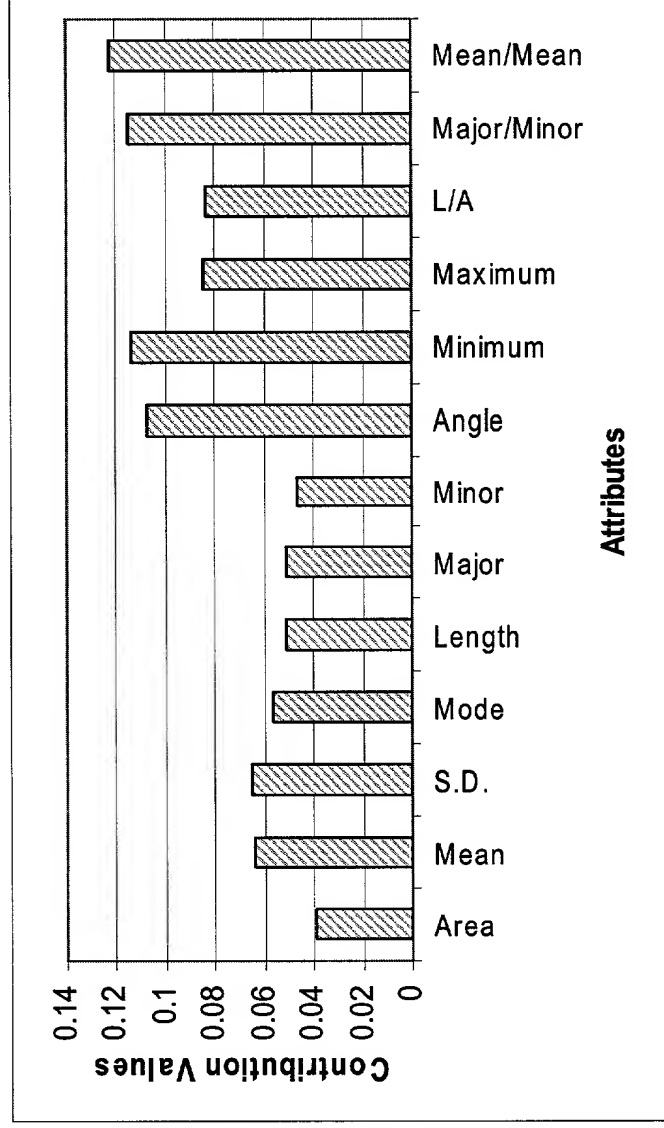


Figure 113: Contribution Values of Attributes Utilized in Designing CrossNet 2

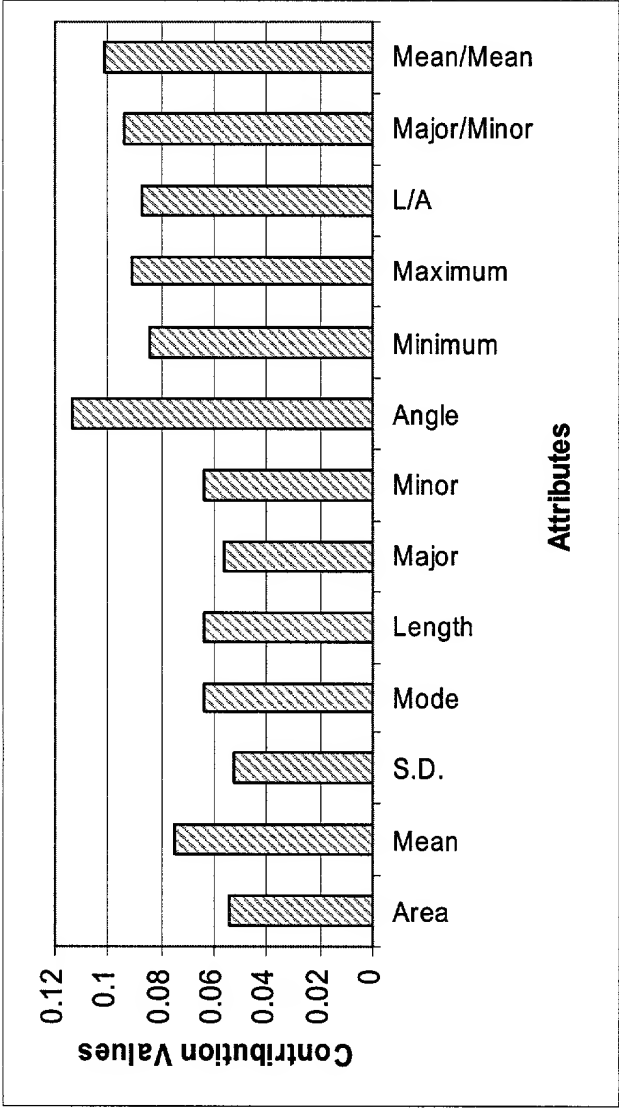


Figure 114: Contribution Values of Attributes Utilized in Designing CrossNet 2

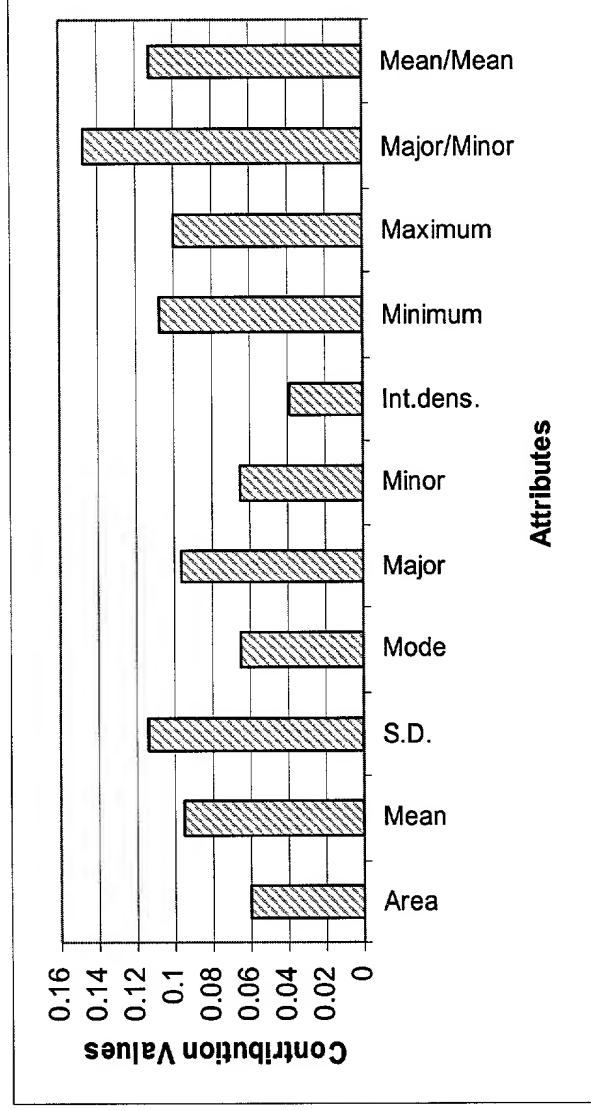


Figure 115: Contribution Values of Attributes Utilized in Designing AlignmentNet 1

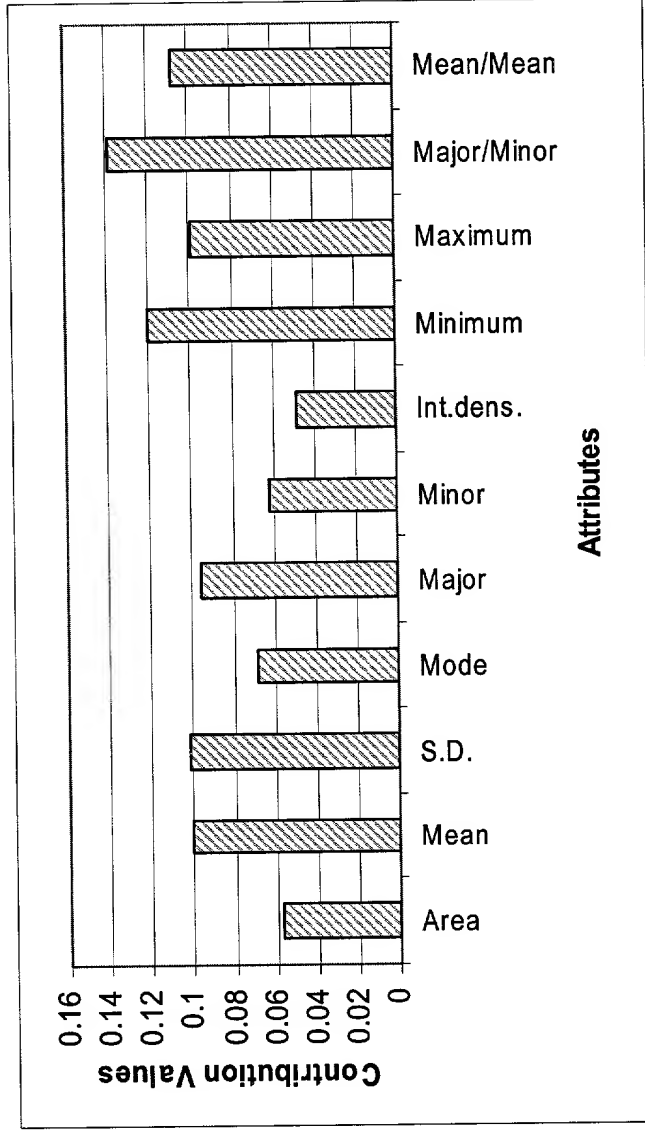


Figure 116: Contribution Values of Attributes Utilized in Designing AlignmentNet 2

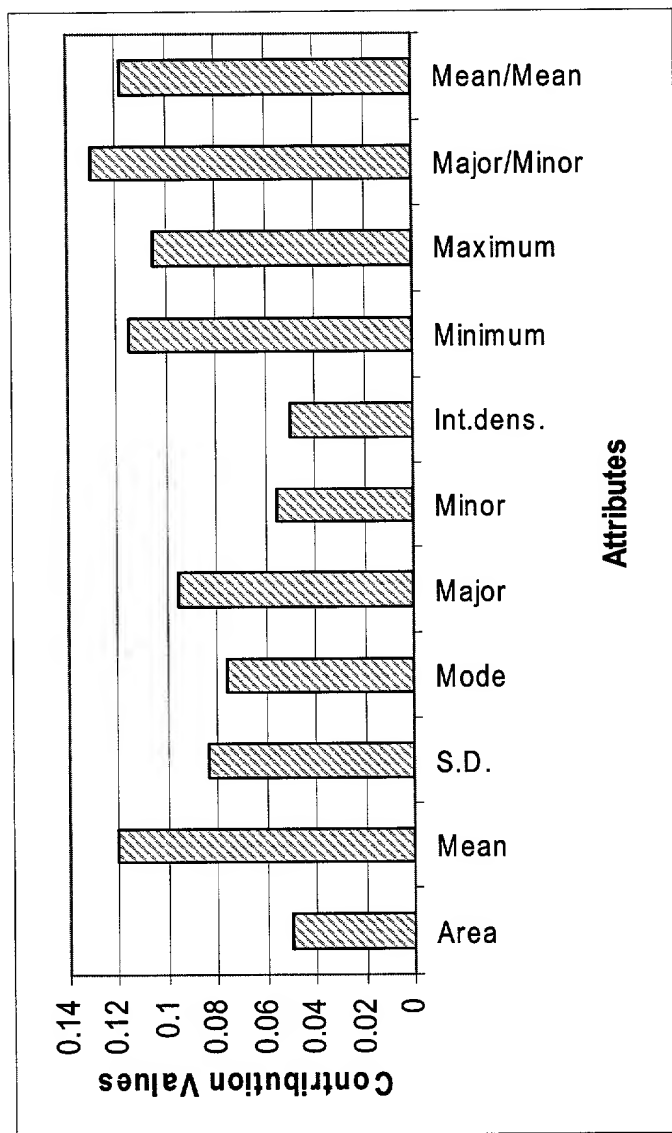


Figure 117: Contribution Values of Attributes Utilized in Designing AlignmentNet 3

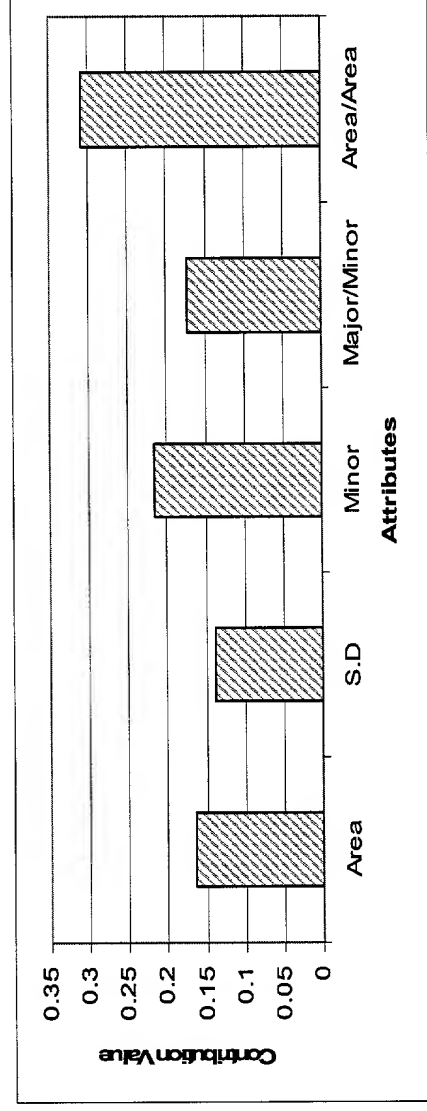


Figure 118: Contribution Values of Attributes Utilized in Designing ModCrossNet 1

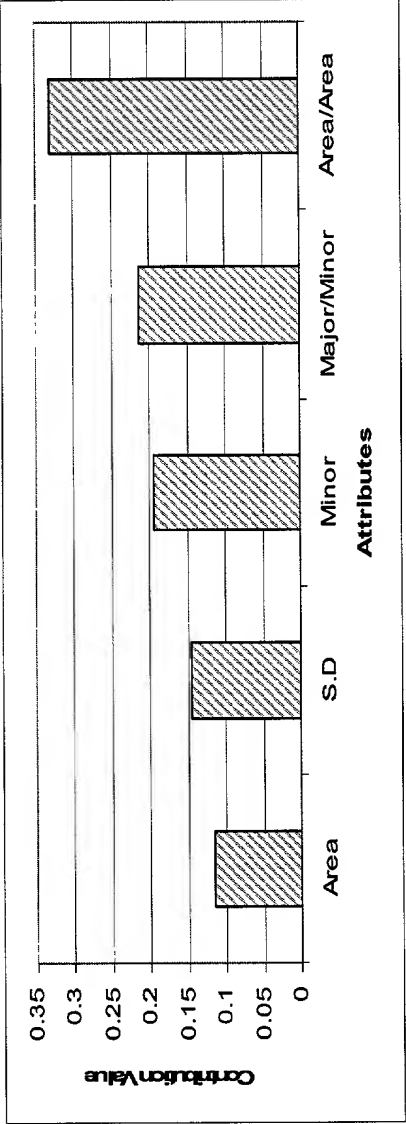


Figure 119: Contribution Values of Attributes Utilized in Designing ModCrossNet 2

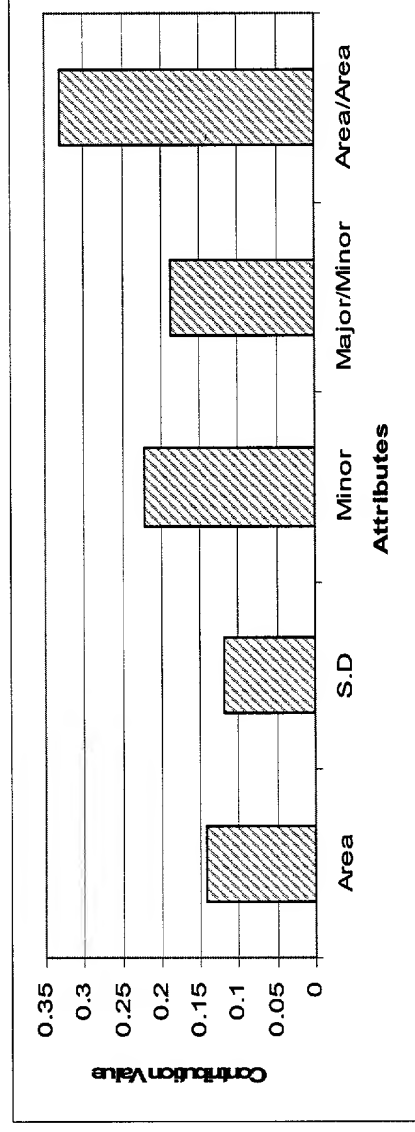


Figure 120: Contribution Values of Attributes Utilized in Designing ModCrossNet 3

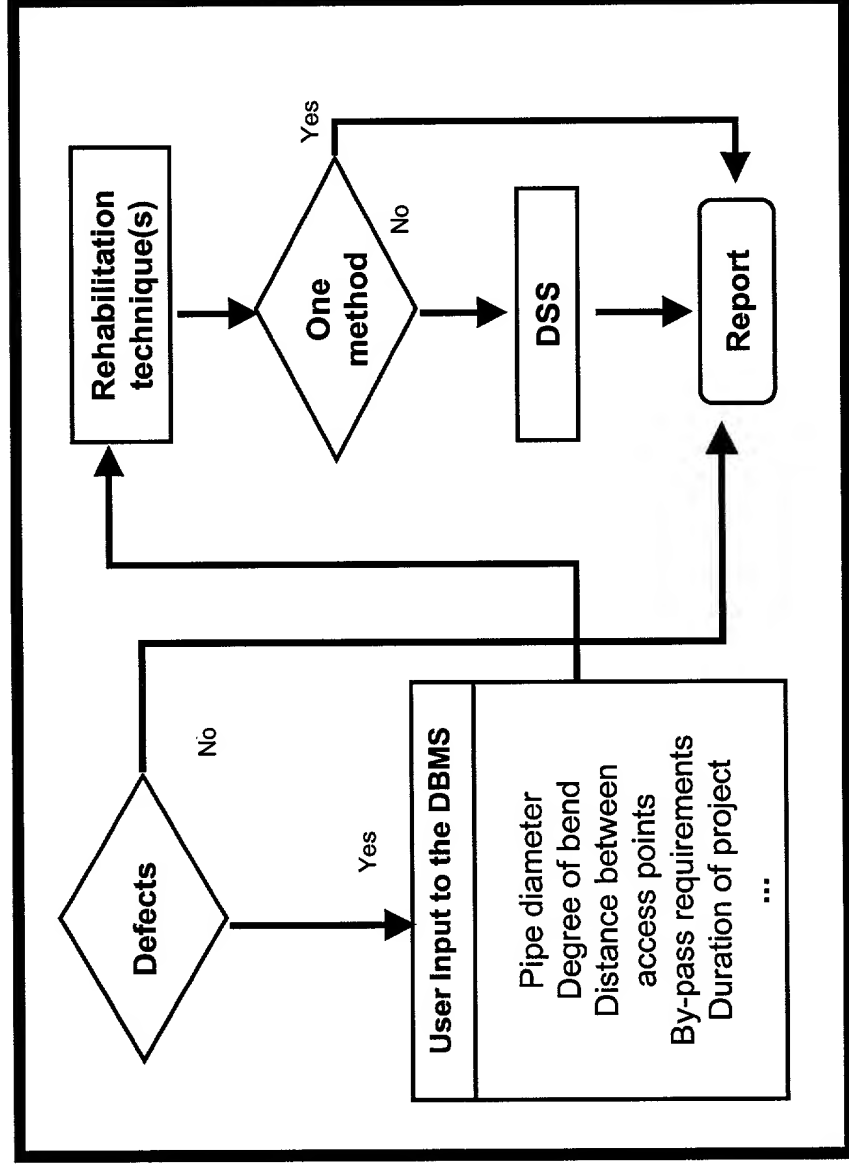


Figure 4-1: Developed Rehabilitation system

products : Table			
	Field Name	Data Type	Description
	ProductID	AutoNumber	Database serial number
	Method of repair	Text	Commercial name of rehabilitation technique
	Maximum distance between access points	Number	Maximum allowable distance between access points to the host pipe
	Maximum degree of bends	Number	Maximum degree of bends of the host pipe
	Average cost	Number	Cost of product
	Average duration	Number	Duration to install 500 (m) of pipe in weeks
	Number of years in business	Number	Years in business of supplier
	Life expectancy	Number	Design life of new pipe
	Local experience	Text	Does the supplier have an Office in Canada
	Access type	Text	Type of access required to the host pipe
	Length of product installed	Number	Number of KM of product installed by the supplier
	Innovation	Number	Ability of supplier to accommodate none standard designs
	Coordinates	Number	Phone number

General

Field Size

New Values

Format

Caption

Indexed

Lookup

Long Integer

Increment

Product ID

Yes (No Duplicates)

Field Properties

A field name can be up to 64 characters long, including spaces.
Press F1 for help on field names.

Figure 4-2: Products Table

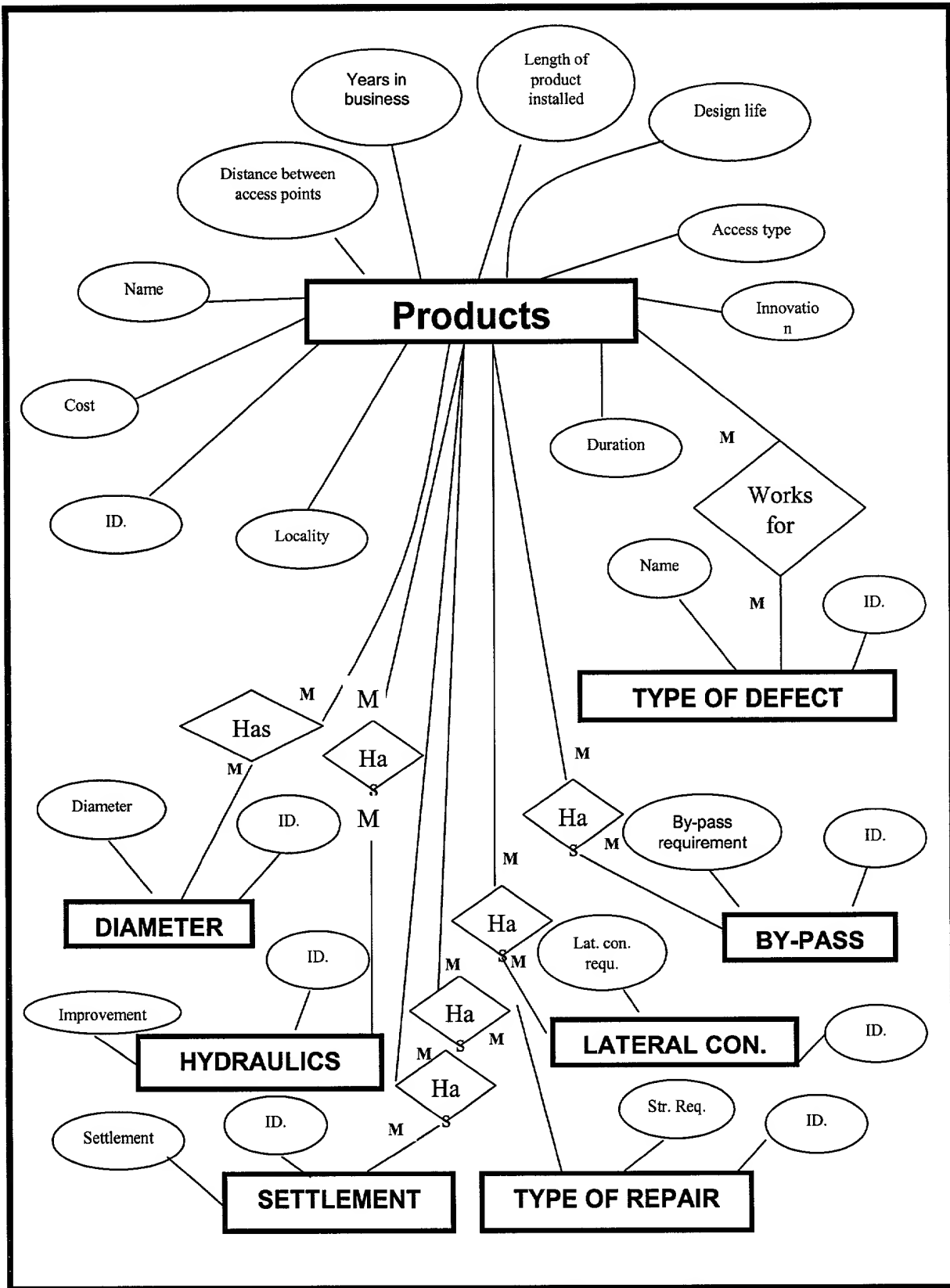


Figure 4-3: Entity Relationship Diagram

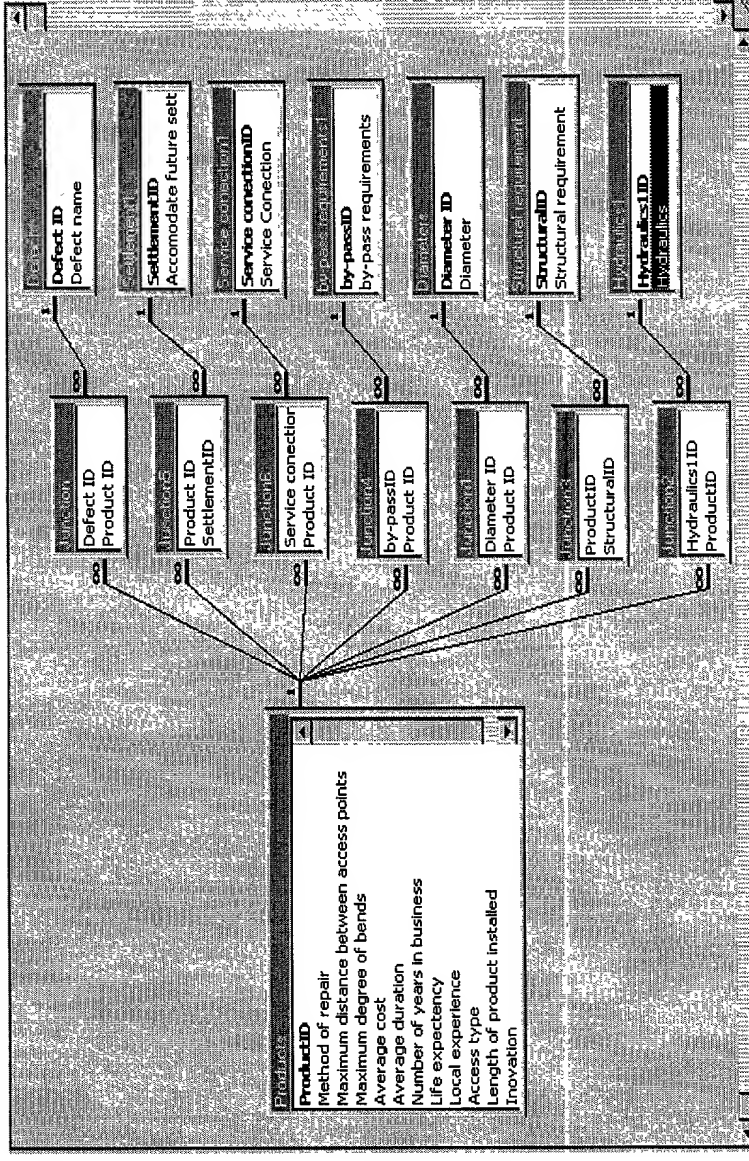


Figure 4-4: Schema of the Developed Database

Figure 4-5: Database Execution Form

The image is a screenshot of a computer window titled 'RUNSCREEN4'. The window contains a form with a large title 'AUTO - SELECT' in the center. Below the title, the text 'Department of Building, Civil and Environmental Engineering' is displayed. Further down, 'CONCORDIA UNIVERSITY' is shown. At the bottom right of the form, there is a button labeled 'RUN'. The window has a standard Windows-style title bar with minimize, maximize, and close buttons.

RUNSCREEN4

AUTO - SELECT

Department of Building, Civil and Environmental Engineering

CONCORDIA UNIVERSITY

RUN

select7: Filter by Form

Diameter [in/cm]

Defect name

Structural requirement [structural/ non-structural]

Average cost [\$ /cm of diameter/m of length]

Maximum degree of bends [Degrees]

Access type [manhole/ manhole/exca.pits]

Maximum distance between access points [m]

Hydraulics [improved/not improved]

By-pass requirements [yes/no]

Average duration [weeks]

Number of years in business [years]

Length of product installed [km]

Life expectancy [years]

Local experience [yes/no]

Accomodate future settlement [yes/no]

Inovation [1-5]

Service Connection [exc. is require/not required]

Non-structural structural

Method of repair

Coordinates

RESULTS

Look for

Figure 4-6: Data Entry and Retrieval Form

UserForm20

Which attributes do you want to consider in your analysis

<input checked="" type="checkbox"/> Cost	<input type="checkbox"/> Years in business
<input type="checkbox"/> Duration	<input type="checkbox"/> Length of product installed
<input type="checkbox"/> Life expectancy	<input type="checkbox"/> Innovation

Next

Figure 4-7: Available Attributes to Users

UserForm22

What, in your opinion, is the most acceptable cost of project...?
(i.e. 100 % satisfaction)

Add

Next

Figure 4-8: Sample Dialog Screen

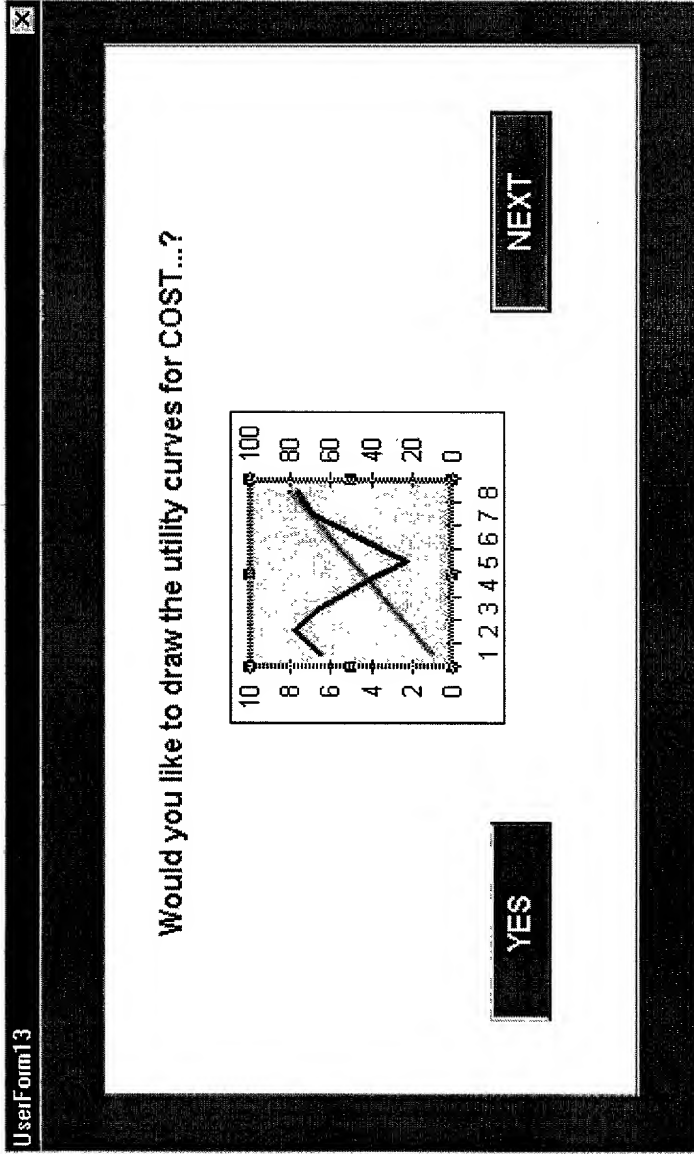


Figure 4-9: Plotting of Utility Functions

UserForm2

WHICH FUNCTION DID YOU SELECT

☒ Linear

☐ Logarithmic

☐ Exponential

☐ Power

☐ Polynomial (second degree)

☐ Polynomial (Third degree)

UP

Next

Down

Figure 4-10: Selection of Utility Functions

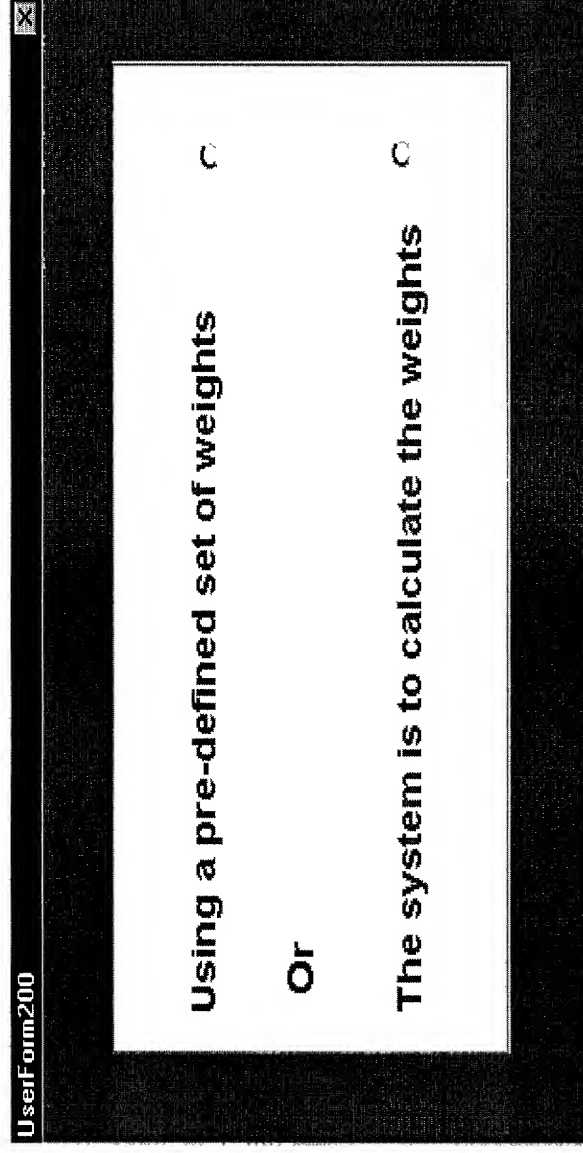


Figure 4-11: Selection of Required Mode of Weight Calculation

UserForm201

Cost

Years in business

Duration

Length of product installed

Life expectancy

Innovation

Retrive file

Load pre-calculated weights

Enter pre-defined weights

Next

Figure 4-12: Feeding a Pre-Calculated Set of Weights

UserForm508

X

File Name

Open file

Figure 4-13: Retrieving a Pre-Defined Set of Weights

UserForm121

	Cost	Duration	Years in business	Life expectancy	Length of product installed	Innovation
Cost	1.00					
Duration		1.00				
Years in business			1.00			
Life expectancy				1.00		
Length of product installed					1.00	
Innovation						1.00

Next

Figure 4-14: Relative Importance Screen

UserForm122

WEIGHT CALCULATIONS

Cost

Duration

Years in business

Life expectancy

Length of product installed

Innovation

Weight

Weight

Weight

Weight

Weight

Weight

PERFORMANCE

Eigenvalue

Consistency Ratio (CR)

Calculate

Revise

Next

Save

Figure 4-15: Weight Calculation Screen

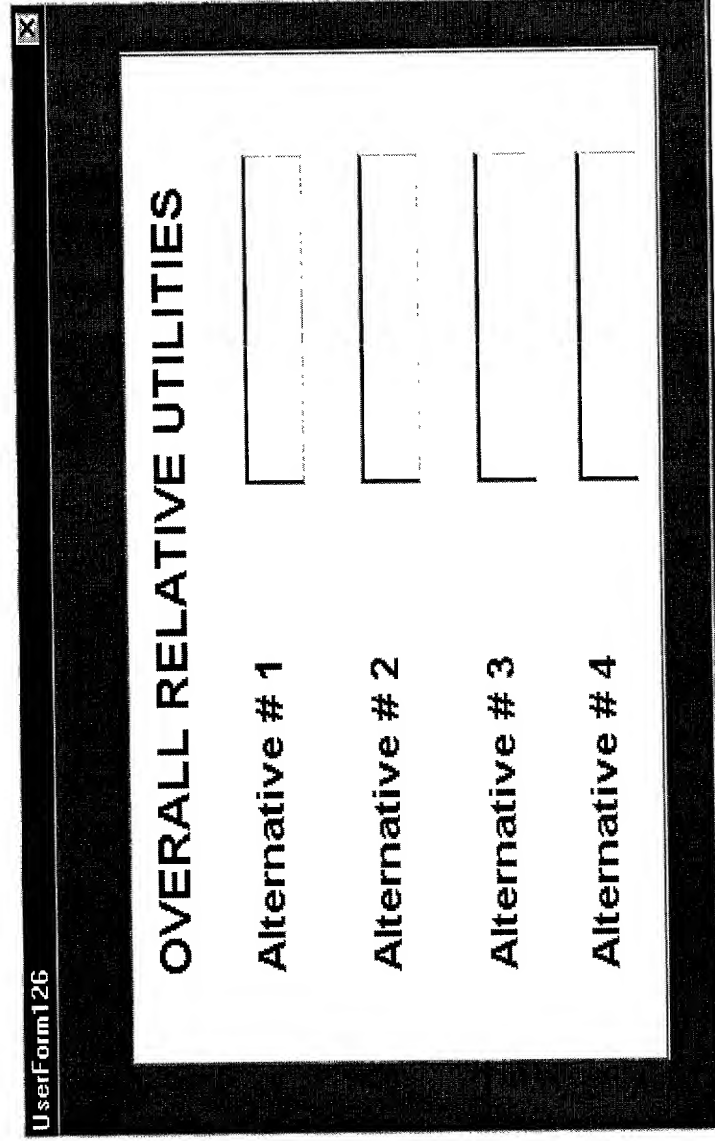


Figure 4-16: Overall Utility Values